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FOUNDED BY C. E. LIDBERGER



**A Journal  
for all  
SCIENCE AND  
MATHEMATICS  
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Mint Growing

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Mathematics in Civil Engineering

Specific Gravity of Liquids

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# School Science and Mathematics

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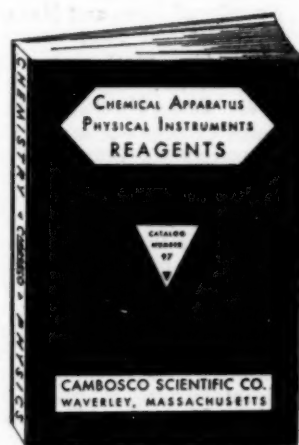
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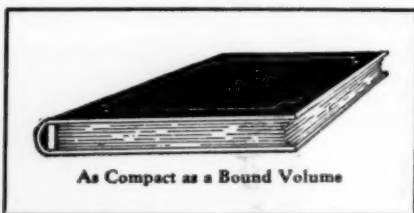
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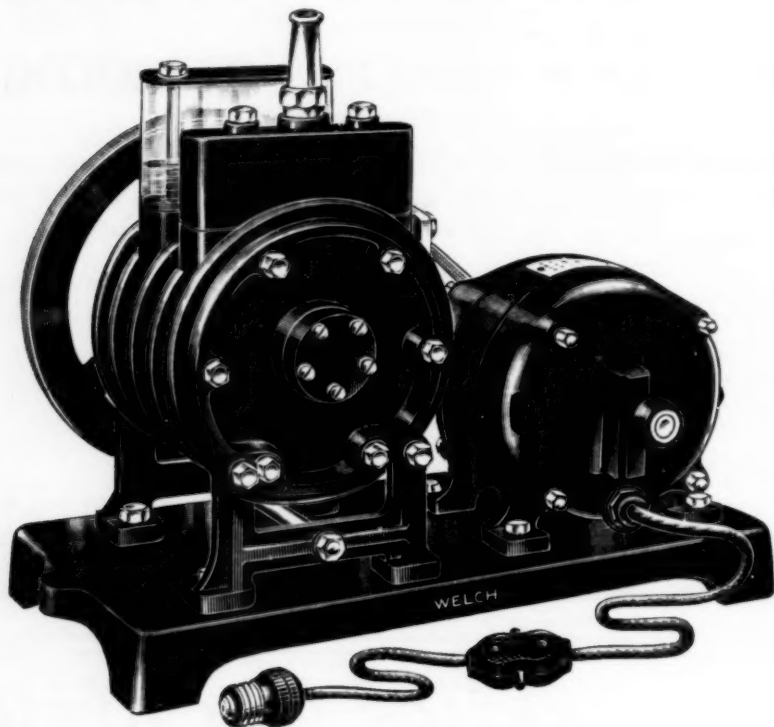
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# SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXV

APRIL, 1935

WHOLE No. 303

## MINT GROWING IN THE UNITED STATES

BY ELIZABETH EISELEN

*Union College, Barbourville, Kentucky*

Peppermint and spearmint are familiar to all of us as flavors in our candy, toothpaste, desserts, or even in peppermint-flavored cod liver oil. Some of us have picked and eaten wild mint from banks and along lake shores, but not so many of us are familiar with the commercial cultivation of mint for its principal marketable product, mint oil. Oil of peppermint is by far the most important of the mint oils, the use of spearmint oil being limited almost exclusively to the flavoring of chewing gum. Since the methods used in the production of both oils are the same, a discussion of peppermint is adequate for both mints.

Mint has been in use for medical and other purposes at least as far back as the ancient Greeks and Romans. A Greek myth relates that the goddess Persephone, in a fit of jealousy, turned her beautiful rival, the nymph Mintha, into the fragrant herb which we call "mint." A legend of the American Indians concerning the origin of the plant is that the Indians' "fever god" was controlled through enchantment by a Pottawatomie Indian princess in whose foot prints there grew a plant whose crushed leaves drove off the evil power of the "fever god."

The Indians and the early settlers collected and in some cases grew mint for private use. Nearly every family raised its own mint. Then in 1815, in Wayne County, New York, commercial mint farming was introduced. It was tried next in Ohio, and about 1825, in southern Michigan. This latter did not prove a

profitable venture; it was not until 1842 that peppermint oil was successfully produced on a commercial basis in southwestern Michigan.

The early plantings of mint were made on upland soils, although it was known that peppermint is a native of muck soils. About 1881, however, it was demonstrated that mint could be successfully produced on reclaimed marsh land. This new practice was quickly adopted, for the yield of oil on muck soils was more than double that obtained from drier lands. The muck furnished the continuous moisture supply which is necessary for the largest development of the plants.

Northern Indiana and southwestern Michigan were fortunate in having large areas of muck land, and the district soon became the center of mint production. In 1929 the two states together produced 734,982 pounds of the 882,723 pounds of the mint oil of the United States. New York has declined in importance with only 12 acres and an output of 550 pounds of oil in 1929.

Attempts have been made to introduce the industry into other areas, principally in the west. Western Oregon was first tried in 1909. In twenty years the industry in Oregon grew to

<i>Production in 1929</i>	<i>Acreage</i>	<i>Pounds of Oil</i>
Indiana	35,913	508,848
Michigan	11,141	226,134
Oregon	2,285	84,333
Washington	846	28,732
California	734	30,861
Ohio	140	2,465
Idaho	19	800
New York	12	550

2285 acres producing 84,333 pounds of oil. At present the western mint fields center in drained land along the Willamette River in Oregon, and along the Columbia River in Oregon and Washington. Recently California has begun to utilize San Joaquin River lands. Production in all mint areas has declined greatly since 1929, due to a decreased domestic demand.

The peppermint plant occurs commercially in two forms, referred to commonly as black and white mint. The "black" mint has dark-purple stems and deep green leaves; the "white" variety has green stems and light-green leaves. The oil occurs in minute glands under the surface of the leaves. The white mint yields a finer grade of oil than the black mint, but is less hardy and less productive. The black mint, therefore, is

now most exclusively grown. This variety was introduced from England into Michigan by A. M. Todd about 1880, when the change was made from upland to muck soils. So successful was Mr. Todd's work in the mint industry that he soon became the leading producer, and he was given the "title" of "Peppermint King" which he held until his death in 1931.

While the presence of the muck land has been a vital factor in the location of mint fields, there is another item—climate—to be considered. Peppermint requires a growing season of 100 to 120 days. The plants are easily injured by late or out-of-season frosts, so the farther north the farmer tries to grow mint, the greater the hazard. Mint does best when it has an abundance of sunshine and warm weather during the latter part of the growing season.



A FIELD OF MINT IN SOUTHERN MICHIGAN

The new fields are usually propagated with runners taken from a field selected for this purpose. More recently experiments have been made in planting with young plants. This has the advantage of enabling the grower to wait until the danger of cold weather is past.

A field is not replanted until the quantity of oil produced from the old plants has diminished to a point where there is no longer a profit. The frequency of replanting varies with the climatic and soil conditions as well as the market price of mint oil.

Since the mint leaves contain the maximum amount of oil when the plants are in bloom, harvesting takes place at or as near this time as is possible. The new mint is cut by scythe; the old mint sometimes by a mower. The mint is then left to wilt.

The next step is the removing of the oil from the leaves. For this process the mint is taken on a hay rack or in tanks made especially for this purpose to a mint still. There the mint is packed tightly into a distilling tub, six feet in diameter by six or eight feet in depth. A lid is fastened onto the tub



MINT READY FOR THE DISTILLERY

and steam passed up through the mint. The oil vaporizes and passes out with the steam through a condenser where it is cooled. The oil with the water thus obtained is then drawn off into storage cans.

The distilleries vary in size from small one-tub outfits, which are the most numerous, to the eight-vat still on the A. M. Tood farm at Mentha, Van Buren County, Michigan. This latter, if not the largest, is one of the largest mint distilleries in the world.

When the oil has been extracted, the mint hay may be dried and stored for feed. Its feeding value is about equal to that of timothy hay. Or it may be returned to the land as fertilizer.

The yield of oil varies according to weather conditions dur-

ing growth, the character of the crop, and the geographic location. In Michigan and Indiana the yield of oil from new mint ranges from 25 to 50 pounds per acre. In Oregon and Washington the average is 50 to 55 pounds, with yields reported as high as 80 and 90 pounds to an acre. In California the crop is cut twice during the season, so the yearly average is still higher. Second year mint yields 50% to 75% that of the new mint with a continued decrease each succeeding year.

The price of oil fluctuates greatly. In 1897 it was 75¢ a pound, rising to \$9.00 in 1920, and then dropping to \$1.25



A. M. TODD MINT DISTILLERY

in 1921. There was a crop failure in 1924 which raised the price to \$10.00 in February 1925. In January, 1926, it reached an all time high of \$35.00 a pound. At that time a shipment of mint oil was so valuable that it was accompanied in transit by armed guards. This record price was due to late spring frosts in the midwest which caused less than half of the planted acreage to reach harvest. The producer in December 1933, was receiving about \$1.90 per pound of strictly choice oil of peppermint.

The United States is the leading country in the production of peppermint and spearmint oils. Statistics of world production are not available, but England, France, Germany, and Italy produce small quantities for local use. Japan produces extensively a variety of peppermint that yields oil differing from that

of English mint oil. Japanese peppermint oil has a less fragrant odor. The Japanese mint is the only commercial source of natural menthol and is used largely for this product. Japan had 40,065 acres devoted to this crop in 1931.

The United States has an increasingly important export business in mint oil. The quantity of peppermint oil exported has increased 48% since 1927, this in spite of the world depression and a marked decline in domestic production. The value of exports, however, has declined. 176,718 pounds of mint oil valued at \$604,320.00 were exported in 1928; in 1932 the figures were 262,210 pounds and \$455,017.00. Only 7600 pounds of peppermint oil valued at \$5,000.00 were imported into the United States during 1932. American peppermint oil has a wide distribution in the world markets. The United Kingdom customarily takes over 50% of the export either directly or as a brokerage market. The figures for the principal countries to which we exported mint in 1928 and 1932 are as follows:

	1928	1932
	(pounds of mint oil)	
United Kingdom.....	88,019	148,985
Germany.....	23,634	34,706
Canada.....	17,816	18,966
France.....	6,969	18,900
Australia.....	5,603	13,743
Netherlands.....	10,656	9,253
Argentina.....	2,340	4,158
Mexico.....	1,797	3,452
Sweden.....	1,487	2,810
Union of South Africa.....	1,275	1,370
Brazil.....	1,642	1,106
New Zealand.....	1,196	455
Norway.....	3	831

The future of the mint industry in the United States depends upon market conditions. Expansion has been urged, especially in the Western states, for they have the advantage of a larger yield of oil per acre. Michigan and Indiana, however, are favored by proximity to large industrial centers of the country and to the eastern ports. The production for domestic consumption has been declining, but with the revival of industries the demand for mint oil should increase. There is sufficient available and suitable land to supply all and more than will be needed, but care must be taken to avoid exceeding the demand.

## MATHEMATICS IN CIVIL ENGINEERING

BY W. E. HOWLAND,

*Purdue University, West Lafayette, Indiana*

It would be impossible, I think, to over-emphasize the importance of mathematics to civil engineering. By mathematics I mean not only the formal subjects of trigonometry, algebra, the calculus and their many calculating cousins old and young but also, and more especially, that general effective thought process properly called mathematical reasoning which is beautifully exemplified by these academic subjects but not entirely monopolized by them. By civil engineering I mean the planning, designing, and supervision of construction of a Boulder Dam or of a Golden Gate Bridge or of an Empire State Building or of those many similar and, in the aggregate, more important but smaller structures to be seen everywhere. (A complete picture of civil engineering would also include the topographic and economic studies and the many research investigations incidental to such structures as these, as well as the operation and maintenance of them when built.)

When one drives over a great suspension bridge he is trusting his life, whether he knows it or not, to the differential equation that was used to predict the shape and stresses in the curving cables above him as truly as to their mighty strength and just as truly to the thousands of humbler calculations that were required to design and place the many members of the bridge.

On the first job the young graduate is likely to find himself a surveyor, a land measurer, called upon to use skillfully his knowledge of plane and solid geometry and trigonometry and to lay out horizontal circles and sometimes spirals and vertical parabolic curves. He must compute irregular volumes of excavation and regular volumes of concrete in place. He must become quickly a skillful and reliable accountant and have a good knowledge of unavoidable errors and their effect upon his results.

Later, in the designing office, he may be called upon to show plans on a flat sheet of paper of all sorts of irregular three dimensional objects—roofs and gables, skewed arches, sewer intersections. This will probably tax to the limit that power of imagination or visualization which he may have gained from a study of solid and descriptive geometry.

And then one day he will be called upon to design or to analyze structures for strength, for capacity and for cost. A pipe may be required that must be strong enough to resist a certain interior pressure and exterior load and must be able to carry a given rate of flow of water and at the same time must be economical. This will call for a knowledge of certain branches of applied mathematics, i.e., of mechanics, hydraulics and then of practical cost data. Eventually the problem may be set up in terms of cost as a function of diameter which must be differentiated and set equal to zero to obtain the condition for least cost.

If it be a thick pipe the forces within the shell will involve a differential equation—in this case of the first degree but of the second order. If exterior loads are to be considered the analysis is made still more complicated. If water hammer effects are important the estimation of interior pressures will involve the designer in a maze of difficulties, partly mathematical, and will lead him to the very front line trenches of knowledge where the engineer, physicist and mathematician are shoulder to shoulder waging their eternal war upon the unknown.

Of course he may and often need not go into his problem so deeply; perhaps he will simply make his pipe like another one that has proved to be satisfactory. This is called the exercise of engineering judgment. But, unless conditions *are* the same, this procedure is not likely to result in the most economical pipe, it might result in one that would not carry enough water or, still worse, that would be structurally unsafe. A most unpleasant story could be written of failures of dams, of bridges, and of high head penstocks where the designer, in many cases not a trained engineer, had trusted his judgment in lieu of careful preliminary investigations.

Much of the homage that youth pays to age in the name of judgment seems to me to be mere sentiment, if not downright hypocrisy. When one's elders have, as some of mine do have, a memory that is wax to receive and marble to retain then it is possible for them to remember the solutions of old problems and thus often to judge aright without waiting to ponder over bulky tomes or to carry through lengthy calculations. But I would be willing to pit my poor reason against their great memory so highly do I regard the power of living thought. If this attitude seems to be due to egotism call it rather the idle fancy of a vagrant mind.

In civil engineering conditions rarely are the same on one job as on another. Nearly every project is unique in some important particular and calls for a unique solution. Perhaps this is not so in mechanical engineering where after the first model T Ford is built one simply multiplies by a million or so. One would not dare to push this analogy too far lest there be a mechanical engineer in the audience.

If it be true that a great amount of mathematical skill is now demanded of the civil engineer how much more is it likely to be true of the next generation whom we teachers are now training. Old empirical formulae based upon the properties of a single material like steel will have to give way to more general and rational formulae adaptable to the new materials and fabrication methods constantly being developed. Aluminum and her alloys have been made available in structural shapes similar to those of steel. Welding is replacing riveting. Reinforced concrete, a composite substance, is universally accepted as an important building material. Each of these innovations has required a new and deeper insight into the elastic behavior of materials. As the demand for economy of weight, and of cost, becomes more urgent the theories must be made more exact and therefore more complex, difficult and mathematical.

I can best illustrate this growth of the importance of Mathematics in civil engineering by reviewing the training of engineers in my own family. My grandfather was a builder of ice houses—those large wooden structures that used to spoil every view along the Hudson River from Poughkeepsie to Albany. He was the engineer, contractor, and boss carpenter—nearly the whole show and yet he could hardly keep accounts; grandmother did that for him. Long division nearly had him stumped. I don't think he figured the strength of a structural member in all his life any more than did the builders of the Gothic cathedrals. Like them, he must have depended very largely upon his intuitive structural sense, which, doubtless, is the intellectual raw material of a sound mathematical mind. At any rate it served him well for he was a good builder and his ice houses did not fall down even when the great iceberg inside of them started to bulge and move in the summer time.

When my father went to the Massachusetts Institute of Technology in Boston in 1894 to become a civil engineer his structural training consisted very largely in the solution of simple truss, beam, and column problems and of masonry arches

to which was applied the mechanics of the equilibrium polygon. In the same school twenty-eight years later I had to learn, in addition, how to apply the general elastic equations to certain indeterminate structures where reinforced concrete was the material used. Now at Purdue we expect our students to employ several methods for the solution of very much more complicated rigid frames than I should have been able to solve as a student. My son, who is building a tree house in the back yard, doubtless will have to analyze the stresses in members as complex as the joints and limbs of the pear tree in which, quite without the use of mathematics and solely through his great-grandfather's structural sense, he has thus far avoided breaking his neck.

I could, if time allowed, present detailed evidence from my own humble work in hydraulics and from the very important work of my colleagues to show that mathematical problems of some complexity are constantly arising in our work. I should like particularly to mention an important recent contribution to the theory of indeterminate structures that was made in connection with his design of the Golden Gate bridge towers by my colleague, Professor Ellis, and the work of his predecessor Professor S. C. Hollister, now Head of the School of Civil Engineering at Cornell, who, while at Purdue, perfected and successfully employed analytical and photo-elastic methods of stress analysis in the shell of the thirty-foot diameter steel pipes at Boulder Dam. The solution of both of these important recent Civil Engineering problems necessitated mathematical skill of more than ordinary power.

Electrical engineers have found more use for the so-called higher branches of mathematics than have the civil engineers but even they are considered mathematical low-brows, by our good friends and determined critics from the Mathematics Department. Operational calculus, for example, is likely to be caviar to a civil, it seems to be bread and butter to the electrical, but it is not even spinach to our high priests of mathematics pure and undefiled. But these gastro-mathematical eccentricities and antipathies should not be allowed to conceal the fact that mathematics in one form or another is the everyday fare of every engineer properly so called. And these distinctions between the higher and the lower serve no useful purpose and had better be forgotten. It is for all of us to penetrate as deeply as we possibly can into the mystery of the

problems which confront us by the aid of what ever mathematical or other insight we may have or may be able to develop. And it is for the whole academic community to share peculiar skills for the solution of common problems.

"Pure Mathematics stands on its own feet" said the mathematician in a rather heated discussion with an engineer. "But it doesn't get anywhere, it doesn't go places until it joins company with the practical problem as in engineering" was the retort. It is doubtless pleasant to browse at will on the upland of knowledge mid flower-strewn vistas of airy fancy but there's work to be done down in the valleys among the troubled busy haunts of men.

I present civil engineering as an example of a field of human endeavor in which mathematics has joined company with the practical human problem and has gotten somewhere in its solution. As such an example it should point the way to the successful application of rational, quantitative methods of thinking to other human problems.

How often one hears the statement that scientific methods are not applicable to this unsubstantial infinitely various entity called human nature. "Keep your mathematics for your bridges" say the politicians, business men, and theologians "and leave the human affairs to us." "Very well," I say to these specialists in all things human if not divine, "But perhaps it is not too presumptuous for us to point out how problems closely related to your own and scarcely less complex are successfully solved. Or aren't you troubled by pebbles in your mental shoe?"

When the civil engineer wants to know how much water is likely to flow in a pipe in the base of a dam he casts about for a general principle or theory to guide his thinking. Such theories now, fortunately, are available, thanks to many workers of the scientific past. In this case he would probably use the basic equation of fluid mechanics called the Bernoulli equation. (There is an august and imperial name in the kingdom of thought which mathematicians and engineers alike delight to honor.) In the form in which the equation must be applied it will not be perfectly correct, much less complete; nevertheless the engineer will use it realizing that the uncorrected results obtained from it would be in error. From experience, from published experiments on other similar tubes he might know what the error in this case is likely to be. He would apply a correction factor based upon those experiments or possibly a so-called

factor of safety to cover a wide range of uncertainty arising not only from the error of the theory but also from the uncertainty of the expected flow—or possibly—as is becoming more frequently the practice—he might build a model of the structure and test it in the laboratory and thus obtain reliable correction coefficients to apply to the basic formulae. Then, when the dam is built, he will test the pipe and publish his results so that his work may serve others as a guide for further designs.

The philosophy on which this method of thinking is based has been formalized and dignified with a name by the German philosopher Vaihinger. It is called the “*Als ob*,” the “*as if*” philosophy. The civil engineer says in effect, “Water acts almost *as if* it were a perfect fluid, almost *as if* the Bernoulli equation were correct.” The word “almost” is important for it reminds him that correction factors must be applied if precise results are to be obtained. For that reason perhaps it should be called the “Almost as if” philosophy. But until these correction factors are applied he proceeds by exact, consistent, quantitative, i.e., mathematical reasoning *as if* the water were indeed the perfect fluid which he knows it is not. This little grammatical trick “*as if*” has in it the power of intellectual metamorphosis. It is the great contribution of the civil engineer and of other “impure” scientists to contemporary thought for it enables the complex problem to be simplified tentatively so that the great power of mathematics may be employed.

If, for example, the civil engineer were attacking a problem in pure economics—and surely most of his own problems have at least an economic flavor, it would not disturb him to know that the “economic man” is a fiction—so is the perfect fluid. All that are needed are the appropriate correction factors to apply to the results of the theory. If it were necessary to perform new experiments to obtain more reliable coefficients than are now available it might not be necessary to make expensive full scale tests. He would perhaps test a small scale model as is now being done in the Tennessee Valley, or a larger model say on a scale of 1 to 48 as was proposed by Mr. Upton Sinclair. Only in that case, as you know, California elected, probably for the first time, not to be taken as a model for the rest of the nation.

Of course, no theory is much good unless it does simplify the problem. A coefficient of correction that varies as widely and as unpredictably as the phenomenon under study is of

little value. Whether the theories and corresponding correction factors of economics are of this sort I do not pretend to know. In fact, economic theories, as I understand them, are not well understood. They usually lead me into a mental tail spin. As for the economists, themselves, some one has said that if all of them were laid end to end they would never reach a conclusion.

The first condition for the successful application of a theory is that it should be understood, and that means understandable, and that means susceptible to the systematic and logical methods of mathematics. Thus speaks the civil engineer!

Yet the transfer to economics of the dead framework of an engineering or physical theory, however understandable, would perhaps but barricade the road to truth. What is needed is the living spirit of the method that was used to establish and test the original theory.

I once tried to restate the principles of flood regulation of Dr. Engels, a famous German hydraulic engineer, so as to make them apply to the control of economic floods and subsequent depressions. The first principle sounds plausible without re-statement. It reads:

1. "The stabilization and protection of the banks is the first prerequisite of a successful system of regulation."

The second, like a text from the scriptures, needs exposition:

2. "Mean and low water regulation serves also as flood protection in so far as stabilized river channel facilitates the discharge of the flood flow."

I suppose this could be interpreted to mean that the stimulation of public work during the depression would preserve the standard of living and so the market for goods in the subsequent boom period.

Finally I give in part the third:

3. "Embankments built solely in the interest of agriculture are harmful," which perhaps is sufficient as stated.

The so-called Deane Plan for the elimination of depressions is expounded by its author in terms of a great flood retention reservoir which will supply water to the natural channels at times of low rainfall.

My own hydro-economic rules are empty phrases into which one could pour any meaning he likes. I hold no brief for any of them, still less for the method of arriving at them. "The path of sociology" writes a Mr. Dawson in J. Arthur Thompson's new book "Science for a New World" is strewn with the corpses

of defunct systems of social physics, "social energetics" and "social mechanics." Such systems are but "generalizations that have no significance and laws which are nothing but false analogies." I do not plead for social mechanics but for the application of the same fundamental thought process to social affairs that has raised mechanics to the highest pinnacle of intellectual achievement and civil engineering to that of a respected profession.

But, it will be objected, mathematics may be applied in engineering where events are regular, orderly and predictable,—not, however, in human affairs where reverse conditions obtain. What could be more irregular and uncertain than the weather? Mark Twain said of this most popular of all conversational topics, "If you do not like the weather (in New England) wait a minute." Yet the civil engineer has learned how to deal quantitatively with the weather. The very success of such flood protection projects as the Boulder Dam depends primarily upon the engineer's ability to determine the probable rates of inflow into the reservoir as affected by the rains and melting snows. Mathematics is perfectly at home with variable and varying phenomena. Variation itself can be measured. The rules of this interesting and important game are called the Mathematical Theories of Statistics.

Is it improper to refer to mathematical thinking as a kind of game? Yes and no. Mathematics develops imagination and a certain lightness and dexterity of thought which is death to fixity of ideas. On the other hand it reduces competition to a minimum,—in civil engineering there are few rival schools of thought, few violent protagonists for this or that theory or practice as in commercial enterprises. In his own field, where mathematical thinking predominates, the engineer is anything but opinionated. Out of it, I am afraid, he is as likely as the next man to become an "island of complacency in a sea of prejudices."

One often hears also that the kind of training needed by the man who is to deal with human problems is humanistic rather than scientific. He needs to understand human nature rather than non-human materials and this information comes from the artists and poets rather than from the laboratory specialists.

I do not wish to quarrel with this view. The proper study of mankind is man. I would simply point out that there is no incompatibility in the two kinds of training—an understanding

of Shakespeare does not disqualify the mathematician. A diploma in civil engineering does not mean "Let no one trust this man with human problems." The civil engineer must deal with human phenomena all the time and he has perfected a technique for this dealing which is far in advance of the techniques of ordinary business.

He has made the fundamental discovery that disinterestedness is a necessary condition for straight thinking. He understands the full significance and implications of Pascal's dictum, "It is not permitted even to the most equitable of men to judge in his own cause." He does not advertise his own abilities nor does he buy on the statements contained in advertisements. They have for him the hollow ring of fundamental nothingness. He recommends the purchase of goods solely upon the basis of tests paid for by his client and vouched for by a disinterested third party. He, himself, is the disinterested third party who stands between the contractor and the owner in adjusting disputes during construction and in holding the contractor to his agreements. In order to protect himself against the baser elements of his own nature, and assure himself a respected place in his profession, he joins a professional society with high ethical standards and practices. His income is a fee or a wage instead of a commission. He deliberately and intentionally removes from himself all temptation to bias so that he may be as fair and impartial as a traffic light.

Finally one hears the charge that the mathematically trained engineers of our time are deficient in the warm and generous impulses of the heart,—they are too much like the traffic light perhaps. "Like breeds like" they say. "Men who make machines become machines themselves and mathematical formulae make formularized men." These are disturbing but unsubstantial nightmares of the philologist. One could as easily prove that engineering makes men ingenious because both words are derived from the same root.

Mathematics is not all of any man's life; neither is engineering, but they are very important parts of life in this twentieth century and education must somehow come to terms with them. Said John Dewey: "Our culture must be consonant with realistic science and with machine industry, instead of a refuge from them. And while there is no guaranty that an education which uses science and employs the controlled processes of industry as a regular part of its equipment will succeed, there is every

assurance that an educational practice that sets science and industry in opposition to its ideal of culture will fail."

We often hear the term "cultural atmosphere" as if there were a medium or stream of ideas in which one may find himself which unobtrusively socialize and refine him. The phrase "radiant personality" is not a new one either but I should like to combine them into another metaphor. Ventilation engineers have shown that the human organism can be comfortably warm in an atmosphere quite cool and stimulating if the surrounding surfaces are sending him plenty of radiant energy. The intellectual medium of the technical school is preponderately cool, too cool perhaps, there are only a few blasts of the warm air of the humanities coming to us. But through this head cooling atmosphere of mathematics the radiant energy of the socially minded mathematician can, and often does, shine to warm the heart. Such teachers are the cultural salvation of any educational institution or system.

I have tried to show in this discourse that Civil Engineering employs the specific and general methods of mathematics, and to an ever increasing extent as the profession advances. I have shown in some detail how civil engineers simplify their complex problems so as to be able to apply the mathematical methods and then how they correct the results of the theory to correspond with the facts. I have suggested that the same process of simplification, mathematical reasoning, and test could be successfully employed in other fields of human endeavor which, like civil engineering, involve varying and variable phenomena and require an understanding of human nature. I have argued that mathematical training is not incompatible with such understanding. Indeed, I believe it is necessary thereto. It may be that the teachers of mathematics, or even of civil engineering, are supplying essential training to the very men who will find a way out of the mazes and all-too-human difficulties of our times.

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#### SCHOOL INCOME

The estimated total income for all education from kindergarten through college, public and private, reporting to the Federal Office of Education was \$3,083,808,785. (\$2,459,000,000 for elementary and secondary education, \$567,000,000 for colleges, and about \$58,000,000 for residential schools for exceptional children.)

## BRINGING 'EM BACK TO LIFE

BY WES MINEAR

*Quincy High School, Quincy, Illinois*

The first point we had in mind in attempting to bring our biology classes back to life was the aim. As our courses and our textbooks are now arranged, one teacher bases his aim on the needs of the community, another on the acquisition of facts, another on mental discipline, another on development of the scientific attitude, another on character training and still another on preparation for college work, and while it is true that each teacher turns out students who make good scientists, and excellent citizens, yet it has always seemed to us that in biology, at least, there is one aim that should include and should achieve all of these various aims, and that in achieving this aim a teacher cannot help but develop a scientific attitude, desirable character and acquisition of facts, and at the same time bring his biology class back to life.

Ruskin stated it to perfection when he said, "The object of true education is to make people not merely *do* the right things, but to enjoy the right things; not merely industrious but to love industry; not merely learned, but to love knowledge." If he had referred to biology I am sure he would have said "not merely to know nature but to love her, for a love of nature will very quickly beget the knowledge."

Inherent in every human being is an interest in living things. A child is much more interested in a live dog, cat, rabbit, canary or pony than in colored pictures of them, or in mechanical imitations. Seventy-eight per cent of their toys and playthings are made in the form of some animal or bird. But only too often our unnatural environment and our unnatural method of living prevent any development of this natural interest, and substitute some baser element to take its place. Too often the child's home training reverses that interest into positive dislike or fear. We believe that it is largely up to the biology teacher to prevent this destruction and this substitution.

One great educationalist has explained our proposition when he stated that he was much more concerned in what likes and dislikes his children acquired, in what attitudes and sentiments they built up, than in their achievements or in the grades they brought home. We are firmly convinced that if we, as teachers,

develop proper likes and dislikes, we need never worry about that child's achievements. We also believe that achieving such an aim would benefit the students who quit school after the ninth or tenth grade just the same as those who go on to college or university. We are too often trying to develop scientists at the expense of the other ninety per cent of our biology students. It will probably be more true from now on than ever before, that a man's life will depend more and more on his ability to enjoy his spare time—on some hobby that interests him—and what better, safer, more lasting and more satisfying hobby could a person have than an intelligent abiding interest in some phase of biology.

I shall always remember one of my first experiences as a young biology teacher, fresh from the university. In one of my biology classes I had just delivered a very masterful explanation of the derivation of biology, and had emphasized the fact that it was the study of living things, when one of my bright young sophomores quite completely took all the wind out of my sails. He pointed to my shelves of prize specimens—either mounted, dried, or preserved in alcohol—and remarked that it seemed to him more appropriate to call it pickleology, and he was very nearly right. My laboratory more nearly resembled a morgue and the course I was prepared to teach was far from a study of living plants and animals. It would not have been very appropriate to have called it the "Science of Life."

So that same night we started building cages and aquaria. We moved our precious preserved specimens back into a store room and in place of them we put a cage of snakes, a pair of canaries and an aquarium of gold fish, and then we had a start towards bringing our biology class back to life.

Since that time we have kept our biology laboratory literally crowded with living plants and animals of every description. And here are a few of the results that such a laboratory has produced:

It has served as an incentive for hundreds of individual field trips that are made outside of school hours. It amalgamates plant, animal, and human biology in a natural sequence. It develops initiative on the part of the student. It forms a work room in which the pupils enjoy their work. In developing a sympathy and reverence for plant and animal life it fulfills one of the important obligations of every teacher of biology—the teaching of conservation. It develops that vital inter-depend-

ence between research in the laboratory and research out in nature. It furnishes the enthusiastic student with a ready outlet for his enthusiasm. It furnishes extra credit work and countless special projects, but best of all it does develop interest, enthusiasm and a desire to learn. We have found it a wonderful means of arousing and sustaining the interest not only of pupils, but also of parents, press and the entire community and if community spirit makes for a better football or a better basketball team why not for a better biology class.

So much for the why. Now for the how and the wherefore.

Such a laboratory is not nearly as difficult as it might first appear. There are three factors that are of primary interest to the already overworked teacher of biology. These three factors are preparation for, collection of, and the *care* of the live specimens. None of the three should be assumed by the teacher. All three are equally fascinating and instructive to different students, and a teacher should restrict himself to organization, inspection, information and approbation.

The biology laboratory can and should be the product of the students rather than of the teacher. The more initiative and the more responsibility they are allowed, the more interest and enthusiasm they will develop and maintain and the more lasting knowledge they will acquire.

The first factor is the preparation of the vivaria, terraria, aquaria, cages or whatever you wish to call them. This, of course, depends entirely on available means and space. The cages and other equipment can either be purchased or built. This is where a good manual training department comes in handy, for any boy in the class who is at all handy with tools can make cages just as practicable and serviceable as those purchased through school supply houses. It makes an excellent project for that type of student. As for purchasing them—once a start has been made, community interest that is bound to follow will influence the school board to purchase what cages and other equipment the teacher needs for the care of living plants and animals. In the last few years school supply houses have been waking up to the need for such equipment and are annually listing a bigger and a better line, and with the increasing demand the supply is becoming cheaper as well as more complete.

The preparation of the equipment for their new occupants is one of the most interesting phases to certain of the students

and if the teacher assumes too much of that responsibility he is simply robbing that type of student of a wonderful outlet for his enthusiasm and of an excellent incentive for learning ecology. That phase of the work requires numerous trips into the fields and woods in order to find out just what factors do make up the natural habitat of the organism. The important factor in preparation of both cages and aquaria is to duplicate the natural environment just as closely as is possible, for it is habits, behavior and ecology that we wish to study instead of detailed morphology and taxonomy. That is really the keystone to a laboratory of living things. That is what makes it a collection of nature's interesting homes and their inhabitants, rather than a jumble of captive animals, and it is much better to have a few well-prepared exhibits than many of the other kind.

The collecting of specimens furnishes an attractive project to a third type of student and furnishes a wonderful means for developing ingenuity, initiative and interest. The more of the collecting that is done by the teacher the more that type of student is robbed of an opportunity for displaying and for developing his ability. That does not mean that field trips by the entire class are unnecessary. A few such trips are more imperative than ever, but more as samples, to illustrate ecological and seasonal successions, to show what a wealth of material can be found in even the most unpromising places, and to develop the pupils' powers of observation. For every trip made by the *class*, hundreds will be made by small *groups* and by individuals.

*Out-of-season* plants and animals are always a challenge to a student's ingenuity. Every year during January when the ground is well frozen and usually when it is covered with snow, we ask some student in each class to bring in a dozen earth worms. And while they are usually completely non-plused at first, they are quite proud of themselves when they finally figure out that the ground won't be frozen under some hayrick or manure pile, and they never yet have failed to bring in the worms.

Among the insects, the clothes moth makes an interesting study and it is surprising how few people either know the adult moth by sight or know anything about its life history. The clothes moth is a pest that can be of real *service* in interesting parents and community in your biology course; and a complete knowledge of its life history, habits, and control will save your

community much loss from their destructive habits. The silkworm, mosquito, meal worms, and roaches make interesting life history and habit studies and, of course, the observation ant nest. Right now two of our students are working on an observation bee hive in the laboratory, where they can study the life history and habits of honey bees just as you can in the largest zoological gardens.

A few aquaria stocked with aquatic larvae make an interesting study. Two of our students have been concentrating on the various singing insects and have become quite fascinated with their work. The ant lion always makes an interesting study, and one that requires practically no effort or care. Last week one of our boys came to school with a cage of fleas and three ticks that he had abstracted from his pet dog and he is quite interested in studying not only their habits but also their structure. Spiders, tarantulas and scorpions make unusually interesting and instructive exhibits.

Among the worms, we always have the ordinary earth worms, sandworms, dew worms—or night crawlers, as we call them—vinegar eels, and we usually have a few horse-hair snakes on hand. The mollusca may be easily represented by land and water snails, slugs, clams and mussels, the crustacea by crayfish and hermit crabs.

With the vertebrate animals the question will be more where to draw the line, how to keep the collection small enough, rather than where to get the specimens, because once it becomes known that you have an interesting collection of live animals, they will come in from all directions; not only from students but from alumni and town people. Hardly a day goes by but what some outsider calls us up to tell us he has a specimen for us.

Among the fishes, various tropicals and gold-fishes are always available, and interest the students to such an extent that a large per cent of them build aquaria and pools at home so that they may enjoy and study some of their own. At least twenty species of wild fish are available and do well in the aquarium that is properly balanced. We have managed to keep eels, sturgeons and spoon bills for several weeks at a time. The various darters are always available as well as sunfish, minnows, catfish, perch, carp, bass and croppie.

Among the amphibia, the life history of the toad and frog is quite interesting and educational and can be easily illustrated right in the aquarium. Numerous salamanders, newts, mud

puppies and hellbenders will find their way into the biology laboratory and the people of the community will be almost as interested in learning something of their habits, as the students themselves.

The reptiles furnish us with abundant material for our laboratory. Lizards adapt themselves to a cage in the laboratory quite readily. We have had as many as nine different species at one time. Their feeding habits are interesting and their food is very easily supplied. Any of the non-poisonous snakes are ideal inhabitants of your laboratory; and we usually keep at least one of each of the poisonous types found in the United States. Any poisonous specimen must, of course, be kept under lock and key in perfectly secure cages. Small alligators, turtles and terrapins are easily collected and quickly adjust themselves to captivity.

Of the bird family, canaries, finches and parakeets are probably most desirable. Small owls and hawks are easily kept. Most of the other birds can only be caged for a day or so and must then be released. At Quincy we are favored in having several men who are greatly interested in bird-banding and they bring us many interesting and unusual specimens of birds that they have banded. We use them for class that day and then set them free and the students become quite interested in bird migrations and bird habits.

The smaller rodents are possibly the most satisfactory of the mammals. White rats, mice, shrews, ground squirrels, chipmunks, flying squirrels, rabbits, guinea pigs, ground hogs, and gophers find their way into our laboratory some time during the year. This year we have had two foxes, two raccoons, three possums, one red-tailed hawk, and three great horned owls. Some of them find permanent homes there, others just stay with us for a short time and then give up their cages to new specimens.

We have always found both our state departments of game and conservation and our State University very willing to assist us and we are quite sure each of you will find that they will gladly cooperate with you. At the present time our students are experimenting with various foods on a group of sixteen white rats that our University sent us. Several times our local game-wardens have taken their seines and secured us a nice collection of native fishes.

The third factor—care of the plant and animal guests—must be carefully planned and supervised by the teacher but the

actual work should all be assigned to various students. Any one of several plans is perfectly feasible and should prove successful. We use a curatorial or monitorial system. During the home room periods both morning and noon we have boys and girls who are especially interested in biology, report in the laboratory and spend the home room period in taking care of our plants and animals. We have over a thousand plants in our conservatory. Every one of them was either donated by townspeople or propagated there in the conservatory, and they furnish our students with plenty of actual experience in testing and fertilizing soils, in control of insect and fungus diseases, in budding and grafting, seed selection and all the various problems that affect horticulture. We have almost forty aquaria, ranging in size from three gallon to five hundred gallon. At various times we use from thirty to fifty cages to display our live animals and yet we find that it throws very little extra work upon the teacher and that the results far more than compensate for the extra trouble. We find that our laboratory is one place where interest, enthusiasm and competition run high; where many problems arise that test the student's ability to think clearly and scientifically. It gives them practical experience in food selection, fresh air, first aid—how to prevent the spread of plant and animal diseases and how to improve plants and animals for our own uses, which in itself cannot help but teach adaptation and modification in form, structure and activities. The solution of these problems gives the student understanding of and practice in those study skills and elements of scientific thinking which are significant in the field of science.

We firmly believe that such a laboratory is one place where a student could and would acquire a very fair knowledge of biology without any help from a teacher. We think it is a very definite proof that activity is the best promoter of interest and the best method of learning and we do know that it has brought our biology classes back to life.

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It is estimated by the Federal Office of Education that more than 833,000 students graduated from high school in 1931-32. There were 138,000 students graduated from first-degree courses in colleges. The Federal Office of Education also estimates that in 1932 there were 1,900,000 living college graduates and 8,100,000 living high school graduates who had not continued their education through college. The Statistical Summary announces that of every 1,000 persons 21 years of age and over in 1932, about 25 had college degrees and 109 had high school diplomas.

## WHAT SHALL WE TEACH IN CHEMISTRY?

BY G. M. BRADBURY

*Lakewood High School, Cleveland, Ohio*

The real and ultimate test of the quality and value of chemistry instruction lies in an unbiased consideration of what the instruction has done to the pupil. Real learning to the point of mastery, of course, is a modification process, one in which the learning goes into the actions and feelings of the pupil. A chemical principle well learned becomes a part of him to influence his future thinking. A chemical skill actually mastered will modify his manner of doing things. A chemical appreciation really attained will change his way of looking at matters of a chemical nature.

While this interpretation of the task confronting chemistry instruction may sound greatly optimistic, it is not quite an impossible undertaking. And anything which can be done in bringing it to a more complete realization certainly is a worthy move in the right direction. If we fail even to approximate such results, the fault is not entirely our own. It surely cannot be said that we are teaching so poorly when we are doing the best we can with our extremely large classes of pupils, many of whom, I am safe in saying, are poorly prepared to study real chemistry, often do not have the attitude of good learners, do not know even how to read well, much less know how to study effectively. If the present chemistry instruction is inadequate, perhaps we are trying to spread a little paint over far too much surface with the result that the covering becomes too thin. Can it be that we are trying to teach too much? Are we expecting too much of our young learners? I hardly think so. Are we expecting them to learn too many facts in chemistry? That may be. Are we still overburdening our courses, our pupils, and ourselves with too much descriptive matter in chemistry with the result that we cannot teach and the pupils cannot hope to learn the real principles of chemistry to the point of mastery?

As long ago as 1902 Alexander Smith struck a strong note for improving the chemistry instruction in high schools when he wrote, "At present much time is wasted on the study of the superficial aspects of chemistry, and the work in the average school is not a trial worthy of the powers of the pupils." Later, as we all know, his *Elementary Chemistry* did much to put his

ideas of the proper type of chemistry instruction in high schools into practice. And it is to be hoped that the trend away from too much descriptive chemistry will continue.

No doubt Alexander Smith was not bothered and certainly not hampered by a long list of objectives in science or in chemistry. Is there any doubt though that in somewhat the manner of the genius-teacher that he was, he sensed and was able to keep constantly in mind the big ideas which were to be planted in the minds and in the actions of his students and pupils.

If the rapidly growing size of the chemistry textbooks is a reliable criterion, we are not sadly in want of less superficial chemistry materials in our secondary schools. However, is it not worth wondering in this case if we should consider the question from the standpoint of depth instead of expanse?

There is a great abundance of textbooks, laboratory manuals, study guides, drill materials, visual aids, testing devices, and so on. And if, aided by a capable instructor, the pupil is able to pick out the big points for mastery from a maze of descriptive matter, he may be able to make rapid and significant progress in learning chemistry. In choosing the best way to proceed along this difficult route, the curriculum workers intend to be his friends and guides.

The great amount of work which is being done in curriculum construction by various committees of several science organizations should begin to crystallize soon. Probably it has already started. If it has, it is well that the process should continue slowly lest many fine-grained but highly scattered ideas be precipitated instead of a few large clear-cut objectives in science instruction.

One of the best lists of science objectives that I have seen is the one proposed by the Wisconsin State Science Committee. Although probably all of you have seen this list, it might be worth reading again. We might accept this list as a tentative basis for evaluating the possible contributions of chemistry to these fourteen objectives which were taken from the responses of a large number of Wisconsin science teachers. As you read the list, if you wish, you might rate them by jotting down a number from zero to five which shows how completely you think it is possible for chemistry to contribute to these large science objectives.

To my way of thinking it is not nearly so important to have these and other objectives stated in words on paper as it is

to have them permeating and continuously filtering through the working minds of science instructors everywhere to control and guide their methods of instruction.

OBJECTIVES IN SCIENCE PROPOSED BY WISCONSIN STATE  
SCIENCE COMMITTEE

1. Command of factual information
2. Familiarity with laws, principles, and theories
3. Power to distinguish between fact and theory
4. Concept of cause and effect relationships
5. Ability to make observations
6. Habits of basing judgment on fact
7. Ability to formulate workable hypothesis
8. Willingness to change opinion on basis of new evidence
9. Freedom from superstitions
10. Appreciation of the contributions of science to our civilization
11. Appreciation of natural beauty
12. Appreciation of man's place in the universe
13. Appreciation of possible future developments of science
14. Possession of interest in science

When we consider a reconstruction of chemistry courses of study, at once two general approaches suggest themselves. One is to discard all the present organization and methods and start anew with a set of objectives based on the life needs of the pupils, select from the great abundance of available materials those materials which best illustrate and bring out these objectives, without much regard for the historical development of the subject, or the necessity for an organized course as it has been judged in the past.

A second method is to start with the present courses in chemistry as they have been taught, scrutinize most carefully all the main principles and methods and materials, and reorganize from the inside outward to a set of controlling principles and objectives. This method would result in a course which will prepare pupils for college entrance and continuation of chemistry in college and at the same time supply the pupils with principles necessary for properly understanding their chemical environment when they have no college-going ambitions.

With a particular class, the instructor can shift the emphasis in either direction toward the college preparatory class or toward the life needs of the non-college going groups.

In attempting to put any plan of chemistry instruction into operation, several well-defined principles of learning should be kept constantly in mind by the instructor. Likewise, the pupils should be aware of these principles. As far as possible they should know where they are going.

1. *The material to be learned should be interesting.* It is doubtful if the scientific interests of young people are separate and distinct from those of adults. There may be, and probably is, a difference in the quantity or depth or permanency of the interests but surely there is none in the quality. Whatever is truly interesting to the chemistry instructor will be interesting to the majority of an average class. If an instructor is filled with an interest in his subject, its methods, values and outcomes, the pupils will not fail to sense the interest. Sincere interest is as catching as the smallpox and usually its results are just about as permanent. Feigned and sugar-coated interest does not fool many of our modern youth with their beyond-their-years intuitive sense of human nature. Yes, the material to be learned should be interesting. This is a study in motivation, the feeling side of the matter, which too often is overlooked in our science instruction.

2. *The material should be valuable.* But what is of value? If the philosophers should come to our aid here, they probably would try to tell us what is valuable in an abstract sense, and we wish to know what is worth while in a very concrete way. They might influence us to accept too many future values, and we want present-tense values.

If we look about us to see what chemical principles are in use by the average person, we will find valuable principles in chemistry. The development of a course from this angle will give us chemistry for the consumer and we need more of it. Then let us choose with great care several industrial processes which not only are important from the standpoint of valuable products but which also illustrate the difficulties and differences in applying chemical principles to large scale production, and which will show clearly the importance of chemistry to industry. This will be producer's chemistry. It may become necessary to reserve the larger part of the more specialized technical chemistry for the industrial schools and the like.

3. *The pupils should know as definitely as possible what they are expected to learn.* Of course, no chemistry teacher even in the rush of checking attendance, answering the phone, replacing broken and misplaced apparatus, getting materials ready for an experiment, etc., would consider making an assignment in this day and age of the new enlightenment by suggesting that the pupils study carefully the section on valence from page 158 to page 165!? Seriously, I believe that it is partly the burden

of textbook writers and manual makers to help the classroom teachers in this respect. If the materials are organized on a unit plan or on a unit-contract plan, a great deal can be done in an interesting preview, overview, forecast, or call-it-what-you-will section to help the pupils know what is expected. And if the expectations consist of a few large ideas to be mastered and applied, so much the better.

In an article on "The Organization of Ideas in General Chemistry," in the *Journal of Chemical Education*, Professor Garard suggests among other specifications that "the entire course should center around a few ideas; certainly not more than fifteen." It is difficult to predict what the reorganization of high school chemistry after a similar fashion would do. For one thing, it might prevent wearing the pupils out physically by lugging around 750-paged chemistry texts. It surely would necessitate a careful reorganization of the material which *did* remain into closely related sections instead of hop-skip-and-jump chapters without any definite plan to follow.

4. *They should receive expert aid in learning how to go about to learn.* In the introduction of a little book on how to study, illustrated through physics, McMurray of the how-to-study fame has the boldness to say, "At present (1926) not one teacher in one hundred would dare attempt to give demonstration lessons showing how to do 'good thinking' in the lessons assigned; and a great majority of teachers could not show the difference between memorizing a text and good thinking." When he says "would not dare," I am not certain what he means, but I have a fairly definite suspicion. After thinking about the above statement, I went into a class and undertook to show them how to study most effectively by thinking through a short section on the chemistry of water. The results certainly are not worth bragging about. Surely if we are attempting to teach boys and girls usable chemistry instead of merely holding classes in chemistry, they have a right to expect aid in learning how to learn. It seems to me that it would be interesting and worth while for some classroom teacher to prepare a little book on how to study chemistry from the pupil's standpoint, a book which could be understood and used also by chemistry teachers. Incidentally, Professor McMurray might be obliged to reduce greatly his 100 to 1 ratio for chemistry teachers in the Central Association.

5. *They should be given plenty of opportunity to put what they*

*have learned into thinking and explaining and acting.* Surely this is the heart of any plan of chemistry instruction. The possibilities for desirable outcomes are so vast and varied that I do not dare try to discuss them.

6. The pupils should be helped to see that complete chemical principles are not learned as a whole, but gradually unfolded as progress is made in experience and training to think chemically. True learning is a growing process. It is a moving out of the fences, as it were, to include more new territory. It is a gradual expansion of understanding and grasp.

A corollary of the above: As the principles become enlarged in the minds of the pupils, greater accuracy in experimental methods, in measuring and expressing results, and in the oral and written interpretation of these results will be the outcome.

If any new materials are needed in chemistry, may we hope that their compilers will have at least some of the above ideas and many more in mind? Progressive education demands new, fresh, interesting, valuable, and more usable materials in chemistry—materials which will develop basic chemical principles, made applicable to the life needs of pupils as well as adults, aids in learning these principles and in applying them, which will literally force chemistry out of the laboratory and classroom into the lives of all who study it.

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#### NEW EDITION OF BULLETIN ON MINERAL IDENTIFICATION

A new edition of United States Geological Survey Bulletin 679, "The microscopic determination of the nonopaque minerals," has just been published as Bulletin 848 and may be obtained from the Superintendent of Documents, Washington, D. C., for 20 cents. The previous edition, which appeared in 1921, was the first reference work to place a systematic compilation of the optical properties of nonopaque minerals at the disposal of the sciences and industries dependent on accurate mineral determination. This work, based primarily on the indices of refraction, determined under the microscope, as the most fundamental diagnostic property of this group of minerals, made possible the wide application of the most accurate method yet devised for their identification. For this reason the earlier edition has been in constant use by mineralogists, mining geologists, ceramic engineers, and others throughout the world.

The new edition of 254 pages has been completely rewritten and the tables brought up to date by the introduction of about 500 new entries and 100 changes in old entries. About 250 new mineral species not given in the old edition are included, and tables have been added in which the data on the important mineral groups have been assembled. The new edition will therefore entirely supersede the earlier one and will be a necessary reference work for all those who have occasion to identify minerals.

## A UNIT ON THE STUDY OF SPECIFIC GRAVITY OF LIQUIDS

BY JACOB W. MOELK

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Coming as it does in the usual sequence of subject matter, toward the end of the study of mechanics of liquids and just before the study of mechanics of gases, this unit can serve several valuable purposes. Its major purpose is to teach the concept of specific gravity of liquids. Besides this it serves to clinch the idea of specific gravity in general. It can clarify and explain the student's experience with battery- and radiator-testing hydrometers, gasoline tests, and similar devices. It affords practice in using and mastering Archimedes' Principle. The idea of direct and inverse proportion can be demonstrated, and finally, it can be used as an introduction to the study of air pressure and the barometer.

This unit is designed to take up two class recitation periods and one laboratory period of one hour each. It is introduced with the help of the hydrometer, since nearly every student has had some experience with this instrument. During the discussion the pupils recount instances where they have used or seen the hydrometer used by a garageman or filling station attendant. They remember seeing test seals on gasoline pumps showing the specific gravity, and some have come into contact with the idea of specific gravity in other places. The school's large laboratory hydrometer is demonstrated along with the small battery and radiator types which have been brought in by the students. Alcohol, saturated salt water, and water are used both in lecture demonstration and in laboratory as representative liquids. After a demonstration of the action of the hydrometer in the various liquids, the concept of inverse proportion is brought in and tied up with the work.

After this the students are asked to think of other possible way of determining specific gravity of liquids. Out of the definition of the term specific gravity comes the quick response, "Weigh equal volumes of the liquids." The specific gravity bottle is then shown to the class and its use demonstrated.

The loss of weight method arises from the statement of Archimedes' Principle. A little questioning by the instructor brings out the idea embodied in the Hare's Tube method.

The advance assignment, to be ready by the next day's laboratory period, is:

Read the material on the subject found in the textbook and answer the following questions and problems.

1. State where the larger numbers would be found on a hydrometer scale and explain briefly.
2. A cylinder weighs 200 gm. in air, 150 gm. in water, 160 gm. in alcohol, and 140 gm. in salt water. Find the S.G. of alcohol and salt water.
3. A bottle weighs 50 gm.  
When full of water it weighs 100 gm.  
When full of alcohol it weighs 90 gm.  
When full of salt water it weighs 110 gm.  
Find the S.G. of the alcohol and the salt water.
4. A stick, weighted at one end floats in water with 4 inches submerged; in alcohol with 5 inches submerged; in salt water with 3.75 inches submerged. Find the S.G. of the alcohol and the salt water.
5. A straw is placed in each of three glasses containing water, alcohol, and salt water. When these three straws are placed in the mouth and sucked on simultaneously, it is found that the water has risen 3 inches, the alcohol 4 inches, and the salt water 2.75 inches. Find the S.G. of the alcohol and salt water.

The laboratory procedure next day is as follows:

Four experiments are performed by the students

1. Specific gravity determination by means of Specific gravity bottles.
2. Loss of weight method.
3. Hydrometer stick method.
4. Hare's Tube method.

Laboratory procedure:

Experiments 3 & 4 (above) are set up before the period. For number 3 an ordinary hydrometer stick 1 cm. square and 30 cm. long, weighted at one end and graduated in centimeters is used. The containers for the liquids are 1 inch glass tubes one foot long, corked at one end and clamped on ring stands.

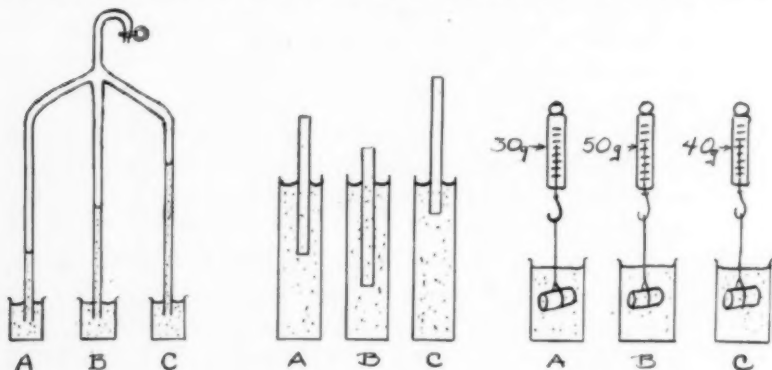
For experiment 4, the Hare's apparatus is modified so that there are three tubes used. In both these experiments each tube is labeled. The liquids used are saturated salt water, alcohol, and water. In order to further distinguish between the liquids,

the salt water is dyed pink with some red ink while the alcohol is tinted a light blue.

The general procedure is fixed well enough in mind by the previous day's discussion and assignment so that the students can go ahead with very little additional instruction in the laboratory. The form in which the data is to be recorded is indicated on the board.

At the opening of the recitation period on the next day, the following quiz is presented:

In each case state whether the liquid is water, alcohol, or salt water:



1. A contains —  
B contains —  
C contains —

The space above the liquids in the tubes is partially evacuated.

2. A contains —  
B contains —  
C contains —

Each hydrometer stick has the same size and weight.

3. A contains —  
B contains —  
C contains —

Each immersed cylinder has the same weight and volume.

4. The height to which a liquid will rise in a partially evacuated tube is (*inversely, directly*) proportional to its specific gravity.

5. The loss of weight of an object immersed in a liquid is (*inversely, directly*) proportional to the density of the liquid.

6. The depth to which a hydrometer will sink in a liquid is (*inversely, directly*) proportional to the density of the liquid.

This quiz, corrected in class, serves as a check on the students grasp of the fundamental ideas. By a show of hands, a quick census can be taken to determine what ideas may require re-teaching. A 15 minute drill on numerical problems involving the various methods will serve, in most cases, to clinch the unit.

Following this, class discussion on the Hare's Tube method serves as an excellent means of approach to the next unit on air pressure and the barometer.

## COMPARISON OF VARIED CURRICULAR PRACTICES IN MATHEMATICS

BY J. WAYNE WRIGHTSTONE

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Of the various departmental subjects of the secondary school curriculum mathematics has been one of the most compartmentalized and isolated. Whether such resistance to change has been due to the abstractness of the subject, or to the inertia of mathematics teachers, it is difficult to say. Even schools which have adopted the newer practices in other departments of the curriculum retain, in teaching mathematics, methods which have been in use for decades.

Since nearly everyone is familiar with standard practices, it will only be necessary for orientation purposes to give a very brief account of them. In the secondary schools where standard methods of teaching mathematics survive, the various branches of the subject are taught in separate courses. In other words, no attempt is made to fuse arithmetic, algebra, geometry, trigonometry and the other branches of mathematics. These various branches of mathematics remain as isolated from each other as they do from the other subjects of the curriculum. Little or no attempt is made to vitalize the abstract subject matter of mathematics with pupil activities. Classes are taught by a group method which allows only a minimum of individualization of instruction.

*Newer-type practices.* In the progressive, or newer-type, junior high schools the general practice is to organize mathematical materials more in relation to pupils' interests and activities than with an unalterable, logical arrangement of subject matter. Such organization is intended to relate the mathematical activities of the classroom to the children's present as well as future needs. A wide variety of interests, other than those of purely mathematical content, are included as part of the classroom activities. When pupil efficiency can best be secured through incidental reviews in practical situations, the modern tendency is to exclude unnecessary traditional topics and materials. In every way possible the newer-type schools endeavor, not only to fuse the various branches of mathematics (as, for instance, arithmetic with geometry); but these schools

aim to correlate the study of mathematics with other courses of the curriculum such as natural sciences, social studies, and fine and practical arts.

In one junior high school system used in this study several experimental practices and factors have been introduced. After experimentation, these schools have endeavored to eliminate from the course in mathematics all unnecessary and obsolete topics and in order for each pupil to progress at an individual rate of accomplishment, drills and skill aspects are individualized. The curriculum, formed on an activity basis, endeavors to utilize the children's interests and experiences. Functional correlation is attempted among the mathematical studies and the other departments of the curriculum. One of the major aims of these experiments, in addition to the development of quantitative thinking, is to relate mathematics with current business and economic problems. Units such as "Financial Relationships of Children to Parents" are developed. In such units drills and skills which are necessary to insure facility are taught as incidental but none the less systematic parts of larger understandings. Courses are organized into goals which pupils achieve at their own individual rates of progress.

The foregoing composite accounts are typical of standard and newer-type teaching practices. In order to compare pupil achievement under both types of practice, two newer-type secondary schools and two standard-type secondary schools were selected, and the pupil personnel of each was tested. The pupils in these schools had similar socio-economic backgrounds, and they were approximately of the same age. Teaching facilities in both types of schools were about equal, and the teachers whose classes were examined had taught approximately the same number of years, and received from their respective supervisors equally high recommendations.

For this study arithmetic, algebra (elementary and intermediate), and geometry were the branches of mathematics which were appraised. These were measured by standard tests in knowledges and skills. On account of the lack of proper measuring instruments it was impossible to evaluate outcomes which might be classified either as dynamic or performance factors. An appraisal of these factors must await further research efforts.

*Equating of pupils for comparative purposes.* In Table I the results of equating pupils on the basis of intelligence are pre-

sented. These average I.Q. scores were secured by giving the Otis Self-Administering Test of Mental Ability, Higher.

TABLE I

AVERAGE SCORES FOR INTELLIGENCE OF SECONDARY SCHOOL PUPILS EQUATED FOR MATHEMATICS TESTS IN NEWER-TYPE AND STANDARD-TYPE SCHOOLS

<i>Schools</i>	<i>Pupils</i>	<i>Average Scores</i>	<i>Standard Deviation</i>
ARITHMETIC			
Newer-type	110	101.90	6.75
Standard-type	110	101.78	6.60
ELEMENTARY ALGEBRA			
Newer-type	90	112.82	9.69
Standard-type	90	112.61	9.66
INTERMEDIATE ALGEBRA			
Newer-type	56	110.00	8.22
Standard-type	56	110.12	8.28
PLANE GEOMETRY			
Newer-type	100	107.36	8.61
Standard-type	100	107.21	8.61

These I.Q. scores are typical for pupils pursuing mathematics courses in the secondary schools. The arithmetic groups, both of the newer and standard-types, have an average I.Q. of approximately 102, which is representative for an unselected group of pupils. The intelligence quotients of pupils taking algebra and geometry are usually higher because of the selective and college preparatory nature of these subjects. The pupils tested for algebra and geometry had an average I.Q. of about 110.

*Intellectual outcomes.* An appraisal of arithmetic knowledges and skills was obtained by administering to pupils in the

seventh and eighth grades of newer and standard-type schools the new Stanford Arithmetic Test, Form W. Ninth grade pupils were tested by the Cooperative Elementary Algebra Test, Form 1933, and the Cooperative Intermediate Algebra Test, Form 1933, was given to eleventh grade pupils. The Cooperative Plane Geometry Test, Form 1933, was administered to tenth grade pupils. The average scores attained by equated groups of pupils in the two types of schools are recorded in Table II.

TABLE II

AVERAGE ACHIEVEMENT IN ARITHMETIC, ALGEBRA, AND GEOMETRY OF EQUATED SECONDARY SCHOOL PUPILS UNDER NEWER-TYPE AND STANDARD-TYPE PRACTICES

<i>Schools</i>	<i>Pupils</i>	<i>Average Scores</i>	<i>Standard Deviation</i>	<i>Difference of Averages</i>	<i>SE Diff.</i>	<i>Ratio</i>	<i>Chances in 1000</i>
ARITHMETIC							
Newer-type	110	95.16	9.94	.29	1.40	.21	583
Standard-type	110	94.87	10.74				
ELEMENTARY ALGEBRA							
Newer-type	90	33.08	16.79	1.86	2.16	.86	805.
Standard-type	90	31.22	11.76				
INTERMEDIATE ALGEBRA							
Newer-type	56	33.11	10.45	8.98	1.94	4.63	999.9
Standard-type	56	42.09	10.02				
PLANE GEOMETRY							
Newer-type	100	32.44	12.73	7.24	2.39	3.03	998.8
Standard-type	100	25.20	20.22				

An inspection of the average scores in Table II shows that in arithmetic, elementary algebra, and plane geometry, the newer-type schools achieved better scores than the standard-type schools, but the better achievement of the newer-type

schools attains statistical significance only in plane geometry. The standard-type schools show a superior and significant achievement in intermediate algebra. The number of pupils examined, however, in all three branches of mathematics was too small to justify a final conclusion. A hypothesis is all that may be stated.

The evidence does indicate, that, in the junior high-school grades, the newer-types practices of fusing arithmetic with geometry and algebra and of centering arithmetic content in current business, social and economic problems permit the pupils to achieve equivalent or slightly superior arithmetic knowledge and skills. The individualized plan of instruction maintains the usual level of skills in elementary algebra, but this plan does not seem to be so effective for intermediate algebra. Plane geometry instruction, when it is individualized and enriched by activities, seems to result in superior achievement in knowledges and skills.

The newer-type practices, as a whole, in the attainment and maintainance of mathematical skills and knowledges are as effective as the standard-type practices. The enrichment of the various branches of mathematics by fusion of various courses, by the introduction of related activities, and by centralization in business, social, and economic problems has not been measured. Certain values are inherent in such practices, but the controlled measurement of the related values awaits further experimentation and research.

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#### **MILE OF HOT METAL RIBBON SLOWS COOLING OF 200-INCH TELESCOPE DISK**

Speed, traditional prime characteristic of American industry, is being most carefully avoided in the preparation of the world's greatest astronomic eye, the 200-inch telescope. In an address before an audience of engineers and technicians, Dr. George V. McCauley, physicist in charge of disk making at the Corning Glass Works, Corning, N. Y., told how this biggest chunk of glass ever made is being kept hot while it is cooling off.

In a special annealing kiln, glowing with electrical heating units using nearly a mile of three-quarter-inch nichrom ribbon, the rate of cooling is slowed down to 1.4 degrees Fahrenheit a day. It will be eight months before it can safely be lifted onto a special car for transportation to its final destination on Mount Palomar, near San Diego, Calif.

Dr. McCauley's discussion of the engineering problems and achievements involved in the preparation and transportation of the enormous slab of glass was presented before a joint meeting of the American Ceramic Society and the National Brick Manufacturers Research Foundation.

## THE WORKBOOK IN MATHEMATICS

BY CHARLES A. STONE

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An educational device that seems to be rapidly gaining favor among teachers is the workbook. Especially is this true in the teaching of arithmetic and secondary mathematics. Because of this large growth in popularity, many superintendents, principals and teachers, who are ardent adherents of the use of the textbook, have termed the workbook a fad and maintain that it will pass into oblivion with all other fads.

Let us examine this so-called fad and see what effect it has upon the teaching of mathematics. The student of the teaching of mathematics knows that ever since mathematics texts were first used, exercises, drills, problems and questions have been a recognized factor in their makeup. In using the textbooks pupils usually copied the exercises and problems upon tablets or sheets of note-book paper and then proceeded to work them out or solve them. Teachers long have realized that this procedure is wasteful both from the standpoint of time and from that of the energy expended, and as a result have resorted to the hectograph, mimeograph and other devices. This meant additional preparation for the teacher and at the same time proved to be costly. Publishers soon became aware of the situation and came to the teacher's aid with printed work materials which relieved the teacher of drudgery and gave to the pupils practice materials resulting from the best educational thinking and research. So we see that the workbook represents a stage in the development of work materials which is normal and psychological.

If the workbook has done nothing else it has stimulated many teachers to break away from the textbook for the first time and thus become independent and perhaps creative teachers. Because of the workbook they have had an opportunity to come in contact with diversified material and have been able to see the value of such material to the pupil. In breaking away from the textbook they have acquired self-confidence and a broader view of the field of mathematics. They have also gained a better understanding of the difficulties and needs of their pupils and of the selection of materials to meet these needs.

From the standpoint of the pupil the workbook is an asset because it relieves him of the tedious task of copying, thus

enabling him to concentrate upon the problems at hand. Under the direction of a skilful teacher the individual needs of each pupil can be provided for, thus making it possible for each pupil to work at his own rate of speed and to attain mastery. The workbook fosters on the part of the pupil many desired habits of work. It develops orderliness, neatness, exactness and thoroughness of work. Through its use the pupil learns to assume responsibility for the successful completion of work because the material in the workbook possesses the characteristics of a project and thus challenges him. Furthermore, in working the exercises in the book daily, the pupil is really recording a history of his achievement which serves to spur him each day to excel the achievement of the previous day. Perhaps this accounts for the pupil's preference for the workbook.

The opponents of the workbook idea also argue that its use imposes an additional expense to the pupil or to the school if the latter furnishes instructional materials. Without considering the educational values derived from the use of the workbook it is not very difficult to see that where the workbook is not a part of the teaching procedure the cost of the paper used by pupils far exceeds the cost of the most expensive workbook on the market. Now the workbook is not a panacea for all ills, but if it decreases the number of failures by making it possible to diagnose pupil difficulties and then applying remedial measures; and if it inculcates in the pupil the desire to accomplish something and do a better job, then the expense entailed by using the workbook is but trivial compared to the expense of re-teaching pupils who have failed.

At the suggestion of the writer Jeanne Willett Ramsey<sup>1</sup> conducted an experiment in order to determine the efficiency of the workbook. She selected four 8A and four 9B algebra classes in a Junior High School in Chicago. The pupils in each of these groups were divided into two sections. The division for pairing the sections throughout the study was made on the basis I.Q.'s obtained by administering the Otis Higher Examination Form A. The standard deviations were also calculated in order to throw further light on the comparisons of the groups. The table below indicates the status of the two 8A groups.

Table I makes it at once evident that the two groups were similar in their intellectual ability, although Section I showed

<sup>1</sup> Ramsey, Jeanne Willett, "A Study of The Value of The Workbook in Teaching Beginning Algebra." Unpublished Master's Thesis, DePaul University, Chicago, Illinois, June, 1933.

TABLE I  
COMPARISON OF TWO 8A SECTIONS ON BASIS OF I.Q.

	Section	
	I	II
Median	99	98.33
S.D.	10.5	9.09

a somewhat wider spread in ability. These sections were taught two units, "Positive and Negative Numbers" and "Addition and Subtraction." While studying the unit on positive and negative numbers, Section I used the Unit Workbook by Stone and Georges,<sup>2</sup> and Section II used a standard algebra text widely used in this country. For the Unit on addition and subtraction the two alternated the use of the workbook and the textbook.

After the teaching of the first unit was completed the two groups were given a test covering the subject matter with the results as shown below.

TABLE II  
COMPARISON OF TEST SCORES FOR UNIT I

	Section I Workbook	Section II Textbook
Median	78.57	60.85
S.D.	12.4	16.4

A glance at the table reveals the superiority of the workbook. Not only does the section using the workbook excel in performance but it shows a less wide spread of scores. Further superiority might be claimed for the section using the workbook inasmuch as its I.Q. distribution has a wider spread than that of the textbook section, while the opposite was true of its achievement scores.

As previously stated for the unit on addition and subtraction the two groups were alternated. Section I was now given the textbook and section II the workbook. Again after the completion of the unit a test was administered with the results as shown in Table III.

<sup>2</sup> Stone, Charles A. and Georges J. S. "Unit Workbook in Algebra." Allyn and Bacon Co., 1931, Boston.

Again the group using the workbook, this time Section II, gave better results than the other group, Section I. It has a higher median and shows a lower standard deviation; yet Section II was inferior to Section I in the first unit, when it was using the textbook. Since the sections using the workbook

TABLE III  
COMPARISON OF TEST SCORES FOR UNIT II

	<i>Section I Textbook</i>	<i>Section II Workbook</i>
Median	79	89
S.D.	16.2	15.9

showed superior performance each time, and since the performance was independent of the nature of the group one can conclude that teaching with the workbook seems to be more effective.

The four 9B classes were likewise divided into two groups and the data concerning their intellectual ability is given below:

TABLE IV  
COMPARISON OF TWO 9B SECTIONS ON BASIS OF I.Q.

	<i>Sections</i>	
	I	II
Median	102.69	101
S.D.	11.6	8.97

The comparative difference in intelligence in favor of the first group in the 9B classes is slightly higher than was the difference in favor of the first group in the 8A classes. The spread for the first 9A group is also wider.

The 9A groups studied the units entitled "The Linear Equation" and "Special Products and Factoring." This time Section

TABLE V  
COMPARISON OF TEST SCORES FOR UNIT III

	<i>Section I Textbook</i>	<i>Section II Workbook</i>
Median	62.3	67.5
S.D.	16.6	13.8

I started with the use of the workbook while Section II used the textbook. At the end of the unit a comprehensive test was administered to the two groups and the results appear in Table V.

For the third time the median of the group using the workbook surpasses the median of the group using the textbook. The spread for the group using the workbook is also less. Thus the superiority of the workbook is again indicated and appears to give better results in the learning process. It should also be remembered that the section using the textbook showed a slight superiority in I.Q.

The 9A groups were then alternated, Section I now using the workbook and Section II using the textbook. When the unit was completed a test was again given with the following results:

TABLE VI  
COMPARISON OF TEST SCORES FOR UNIT IV

	<i>Section I Workbook</i>	<i>Section II Textbook</i>
Median	84.5	53.09
S.D.	12.3	13.9

From the results with the unit on special products and factoring it is seen that the workbook makes a more favorable showing than with the other three units. This is perhaps due to the fact that a great amount of practice is needed in a unit such as special products and factoring, and certainly the workbook provides such practice material.

The investigator finally states that the following conclusions are justifiable and valid:

1. Independent of subject matter and group, the use of the workbook achieved better results.
2. Independent of subject matter and group, the use of the workbook held the class together better in line of thought.
3. Independent of subject matter and group, the workbook produced more high scores and fewer low scores than the textbook.

It was also discovered that the pupils generally preferred the workbook.

Teachers using workbooks were asked to state the advantages of the workbook as a teaching device and as a result the following list was compiled:

1. Saves time and energy for pupil and teacher.
2. Makes the teacher independent of the textbook.

3. Makes it possible to do a better teaching job.
4. Makes it possible to select materials suited to the needs of each pupil.
5. Makes for the assumption of responsibility on the part of the pupil as far as completion of a task is concerned.
6. Challenges the pupil because it resembles a project.
7. Stimulates the pupil to do neat and accurate work.
8. Stimulates the pupil to do a better job from day to day.
9. Makes it possible for the pupil to keep a permanent record of his achievement.
10. Reduces the number of failures.
11. Makes it easier to diagnose pupil difficulties.
12. Eliminates lockstep instruction.
13. Makes it easier to teach the near sighted pupils and those hard of hearing.

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### WASTE DISPOSAL\*

BY C. K. CALVERT

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From early times, the human race has given attention to the matter of proper disposal of body wastes. As people have become concentrated in small areas, the problem has increased in importance. Tanneries, slaughterhouses and food packing plants located themselves originally on watercourses, not only to take advantage of the power and ease of transportation, but on account of the fact that waste material incident to the prosecution of their businesses was carried away by the stream. In most cases, initially, the sewage and industrial wastes produced no serious effect on the stream, in many cases simply affording an increased food supply for fish. With the passage of time, cities have increased in size as well as the volume of work done by industries, and at the same time former river flows have been decreased due, primarily, to the removal of the forests. At the present time most inland cities are unable to dispose of their wastes by discharging them to the stream without producing offensive conditions and causing the death of fish. Practically all sewage disposal plants have been built as a result of complaints made by riparian owners along the watercourses below.

City waste is divided into three main parts. Ashes and other non-inflammable refuse may be deposited in low ground. Such

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areas, after being raised, may be used for building sites or, as is the case in many cities, sites for public parks. After the fill is made, a nominal covering of soil is used in order to support grass, shrubs and even some varieties of trees. The disposal of this material is inexpensive; the cost of disposing of approximately 150,000 yards of ashes in Indianapolis was at the rate of 57.5 cents per cubic yard in 1933.

Garbage, or the refuse from the preparation of food in the home or in public eating establishments, is usually collected weekly in the winter and semi-weekly in the summer from the residence districts and daily from hotels and restaurants, a more frequent collection being necessary during the summer months when putrefaction proceeds rapidly.

Garbage may be used, without treatment, as feed for hogs. This method of disposal is most successful in dry climates but its economy is doubtful on account of the large amount of moisture and inert material which must be transported. In most American cities it is incinerated. This method of disposal offers very little opportunity for the recovery of by products other than some excess heat. Its chief advantage is the odorless and prompt destruction of an offensive material. The by product method of disposal results in the recovery of grease and tankage, the former returning the greater amount of money. Various methods of reduction have been used. The one at Indianapolis consists of cooking the garbage in large tanks under 80 pounds pressure for about two hours, after which the separated grease is skimmed and the liquor drained away. The residual tankage is dried in steam jacketed vacuum tanks and separated by a current of air into light and heavy portions. From the heavy portion, the grease is removed, by the use of naphtha, and this, together with the grease skimmed from the cooked garbage, is sold to soap manufacturers. The residual grease free tankage is sold for use as a fertilizer base and the lighter portions of the tankage sold for cattle and hog feed. In the past six years at Indianapolis there has been recovered, per ton of green garbage, 61 pounds of grease, 168 pounds of fertilizer base and 55 pounds of animal feed. It is calculated that about eight grams of grease are recovered per capita per day. The average return per ton of green garbage has been \$3.10, with the cost of operation \$3.51. Interest and depreciation on buildings and equipment is \$2.75 per ton of green garbage.

As a matter of convenience, whatever waste material may

be water-carried is disposed of by sending it to the sewer. Thus sewage contains not only the body wastes, but much material from the preparation of food and considerable quantities of very putrescible industrial wastes.

The strength of sewage is measured by the amount of oxygen required to stabilize it. It is termed the Biological Oxygen Demand, or B.O.D. As an example of the strength of industrial waste it has been determined that the per capita equivalent of the waste from the manufacture of 100 pounds of butter is 9; the packing of 1,000 pounds of pork and beans, 54; the slaughter of one animal, 25; and the laundrying of 100 pounds of clothes, 24.

Regardless of the method used for the final purification of sewage, its initial treatment is one of sedimentation, or screening, to remove as much as possible of the suspended solid matter. After this treatment, the very finely divided and soluble matter are oxidized by biologic methods. Particularly in the small places the sprinkling filter is used. A sprinkling filter is a deep pit of crushed stone over which sewage is sprayed. It trickles through the filter, traveling over the stone on which bacteria grow. These organisms are able to, in part, consume the organic matter present and, perhaps by enzyme action, effect the oxidation of the greater portion of the putrescible matter in the sewage.

The larger, more modern, installations are the activated sludge type. The bacteria utilized are of much the same sort as those living on the stone in the sprinkling filter. The so-called activated sludge is essentially a culture of bacteria and microscopic organisms produced in sewage by blowing air through it. In actual practice, the sewage, as it enters the activated sludge plant, has added to it activated sludge. It is then kept in constant motion by the addition of air in fine bubbles at the bottom of the tank. With an ample supply of air and of activated sludge, in the course of four or five hours, the organic matter originally present in the sewage is quite completely oxidized and after the removal of the activated sludge, by sedimentation, the liquid is sufficiently pure to support fish life and may be discharged to the stream without killing fish or producing offensive conditions.

There is a very large amount of nitrogen contained in sewage, but the cost of recovering it from so much water (raw sewage being 99.9 per cent pure water) is greater than the value of the

material itself. Part of the nitrogen is recovered as sludge from the clarification of sewage and the activated sludge process. Such sludge may be dewatered and dried but the cost is usually equal, at least, to the value of the material. When there is no market for the dried sludge, it may be disposed of satisfactorily by incineration. In most sewage disposal plants, the sludge is digested under anaerobic conditions which reduce the volume and weight of the solids, after which it may be partially dried and used as fertilizer having a value comparable to that of barnyard manure.

While the wastes of a city contain valuable recoverable material, the cost of recovery usually exceeds the value. On this account, many cities have found it more economical to destroy their wastes in as inoffensive and economical a fashion as possible.

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#### CHEMISTRY ADDS 20 NEW KINDS OF MATTER

Discovery of some 20 new varieties of the chemical elements, called isotopes, was announced to the Royal Society by the world authority and Nobelist, Prof. F. W. Aston of Cambridge, as the result of several years of exacting spectrographic work on a dozen elemental substances.

The census of isotopes kept by Prof. Aston shows that 247 stable element varieties are now known from 79 of the 92 elements.

Isotopes in chemistry correspond roughly to non-identical twins in animals, since they are the same stuff but the atom of one isotope has a different mass or weight than another isotope of the same element.

The new isotopes are of the elements hafnium, thorium, rhodium, titanium, zirconium, calcium, gallium, silver, carbon, nickel, cadmium, iron and indium. They were discovered by mass spectrograph analyses made either by the anode ray or more usual discharge method. The mass spectrograph is an instrument that serves as an extremely sensitive balance for weighing the elements.

Important also was Prof. Aston's announcement that he had discovered rays from hafnium, thorium and rhodium for the first time.

Because an average of three and a tenth isotopes for every chemical element has been discovered, this is taken to mean that there is a stable elementary atom for every whole number weight from one to 210.

"This is an astonishing situation," Prof. Aston said, "and I believe the discovery of many more such isotopes is unlikely at least for many years unless by quite new methods."

Prof. Aston cited with approval the theory of Prof. Gamow, Soviet physicist now lecturing at George Washington University, Washington, D. C., that if more isotopes are discovered they will probably be radioactive, breaking down into other isotopes.

Not content with his pioneering explorations of atom varieties, Prof. Aston said that he would modify his apparatus in the hope of obtaining still finer and more accurate measurements of atomic masses.

## TIME: MATHEMATICAL AND GEOCENTRIC<sup>1</sup>

### Part II. Geocentric Time

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#### A. THE YEAR AND THE SEASONS

In the first part of this paper<sup>2</sup> we discussed certain aspects of mathematical time and we tried to trace in some detail some of the outstanding philosophical and experimental contributions that were fundamental in modifying and shaping our concept of simultaneity and time interval.

We are tempted to mention a number of phenomena that found a beautiful explanation or had been predicted on the basis of relativistic ideas of time, but this being essentially a paper on the various aspects and manifestations of time, we must devote the remainder of this paper to certain phases of it, perhaps a little less bewildering and somewhat prosaic, but nevertheless of profound practical interest and importance to mankind. These aspects of time are revealed and shaped for us and imposed upon us by the peculiarities of the motion of the planet on which we live. We hope that the reader will condone us if we designate the totality of these phenomena and problems as *Geocentric Time*.

The succession of days and nights has furnished since the appearance of man—since the appearance of life itself—a natural and convenient subdivision of time, a subdivision which man by the force of physical conditions uses most and will continue to use for a long time to come.

Man noticed rather easily that the number of successive and similar events that could take place in one day, that is, between two successive passages of the sun through the highest point of its course, remained more or less constant. For instance, he noticed that the distance which he could travel or the material which he could transport between two given points was sensibly the same in these intervals. So he took this interval as a unit of measure. Today we use the same primitive unit for our most precise measurements, and presently we will see up to what point this unit is really invariable. The Greeks called this interval *nuchthemeron*.

<sup>1</sup> A paper read before the Kappa Sigma Gamma Authors' Club of Chicago.

<sup>2</sup> Published in *SCHOOL SCIENCE AND MATHEMATICS*, Vol. XXXV, pp. 44-54, January, 1935.

It will be sufficient for the present to mention that the hour, the one that we use, is the twenty-fourth part of the mean solar day, or is the duration of a year divided by 365 times 24 in an ordinary year or 366 times 24 when we have the bissextile year. Man soon grouped a number of days into more extended units of time. The ancient agricultural people such as the Egyptians, noticed that at the end of a certain period of time the same phenomena were repeated; for instance the cycle of weather or vegetation. They also noticed that the highest point reached by the sun in its daily path was variable, and that that variation coincided with the variation of other physical phenomena such as vegetation, rains, and flood height of water in the Nile. All these facts led them to the idea of the year which embraces and contains the ensemble of periodic and parallel physical events.

It seems well proved that the Egyptians of the XII dynasty (3000 B.C.) knew the length of a year to be 365 and one-fourth days. Their observations included a very precise measurement of the course and the heliac rise of the most beautiful star of the sky—Sirius—which they called Sothis.

The Chaldeans and the Greeks adopted that year from the Egyptians. The Romans ignored that beautiful discovery. Their year included absurdities that are not worth mentioning here. The Roman civil year brought such disorders with the seasons that Julius Caesar, with a dictatorial gesture, adopted the Egyptian year. Such is, summarily, the evolution of the year that enlightened Egypt gave the civilized world through militaristic Rome. Today we know that the purely local agricultural and practical observation that lead the Egyptians to know with the marvelous exactitude the duration of the solar year corresponds to other data, purely astronomical and independent of any geographical contingency.

If we observe the position of the sun during the seasons, the totality of which is the ecliptic line, it will be observed that the sun is alternately above and below that plane that contains the celestial and terrestrial equators. In the summer it is above and in the winter below the equatorial plane. The instant at which the Sun in its apparent motion from the south passes the celestial equator is called the vernal equinox, and the points in the sky where the ecliptic intersects the celestial equator are called the vernal points. The crossing from the north to the south mark the autumnal equinox. Between the vernal and autumnal equinoxes there is a precise moment where the sun attains its

greatest boreal height above the equator. This moment is known as the summer solstice, and from this moment the sun begins to decline towards the south. Similarly, between the autumnal and the vernal equinox we have the winter solstice.

And now, armed with these didactic precisions, a little annoying, but necessary, we will be able to know with exactitude and sureness the year and the interlaced cycle of its dissimilar daughters, the seasons.

Astronomical observations have determined this length as equal to 365.24219879 days, that is, 365 days, 5 hours, 48 minutes, and 45.98 seconds. This number represents the duration of the year 1900. The observations have shown, and this is a very important point, that the duration of the year diminishes by 53 hundredths of a second per century. In 1934 the duration of the year was 365 days, 5 hours, 48 minutes, and 45.81 seconds. These 17 hundredths of a second by which the year has diminished since 1900 seems insignificant for the people who have as a definition of time "time is money," while for the philosophers, this negligible difference is rich in astonishing consequences. The year we just defined, that is, the duration between the vernal equinoxes is the year which astronomers call in their esoteric language, the *tropic* year.

In addition to the tropic year above mentioned, astronomers find convenient to define and use some other types of the year. The *sidereal* year, that is, the time interval necessary for the sun to make a complete circuit among the stars—on account of the singular phenomenon called the precession of the equinoxes—is not equal to the tropic year. The sidereal year is a little longer than the tropic year. A third kind of year defined by the astronomers is known as the *anomalous* year; this is the time interval between two successive perigees and should be equal to the sidereal year if the perigee of the sun were always found opposite the same point of the celestial vault. But, it is not so; the perigee has its own movement among the stars. Einstein has explained this previously incomprehensible movement. The anomalous year is a little longer than the sidereal year. Finally we have a fourth kind of year, the *civil* year, which is used in our everyday life, even by the astronomers, and consists of 365 days in the ordinary year and 366 in the bissextile year. In what follows we will concern ourselves with the civil and tropic years only, and that will be sufficient. Most of the people on the earth are now accustomed to begin their new year,

the civil year, on the first of January. It is an occasion, in many countries, of festivities, of presents, and of other forms of joyousness. In most of the countries of the earth, people have accepted the touching custom of embracing each other at the solemn moment of the night of December 31st when the new year springs forth from the chrysalis of the defunct year as a nimble frivolous butterfly. The civil year begins on the earth the moment of midnight  $180^{\circ}$  west of Greenwich. At this moment our clocks in Chicago indicate 6:00 A.M. (C.S.T.) December 31. There is, then, considerable delay and variation in the time of our traditional rejoicing. The use of January 1 for the beginning of the New Year began in France during the reign of Charles IX. Previously it began on Easter Sunday. In England the same change was made in the eighteenth century by Lord Chesterfield who decided to change January 1, 1751 to January 1, 1752. The people at that time rioted against the noble lord and the cries of "give us back our three months" were heard in the streets innumerable times.

March, despite its warlike and not very bucolic name, is the month that brings back the spring. The sun reascends towards the north and crosses the celestial equator about the twenty-first of March but not always the twenty-first. The precise moment of the entrance of the spring is given for every year in the ephemeris, that official program of celestial festivities. Ordinarily the length of spring is ninety-two days and twenty hours. Its duration added to that of the summer is greater by eight days than that of fall and winter. This anomaly is due to the precession of equinoxes. We enjoy the sun therefore, at the present time eight more days in the northern hemisphere than they do in the southern hemisphere. In the year 1250 the first two seasons lasted thirty-eight more days than the other two.

And then comes the summer which the month of June brings forth about the twentieth of the month. In 1934 the summer solstice began June twenty-first at 8:45 A.M. (C.S.T.). At this precise moment after reaching its greatest height above the celestial equator, the sun began to descend slowly towards the south. The old civilizations celebrated in magnificent and bloody festivities the solar culmination, the signal of summer. Men, similar to heliotropes, at these times lifted their adoring faces towards the sun who in its sanctuary in the blue colored vault was a sign, flamboyant and mystic. Christendom marked with its marvelous adaptability this occasion as St. John's Day. At

this point we may say that the astronomical summer does not coincide with the meteorological summer for the same reasons that the maximum of day's heat is behind the time of the sun's maximum elevation above the horizon. The maximum summer temperature is observed not on the twenty-second of June but during the second fortnight of July, which includes the tantalizing canicular days. The sun in this respect, it has been suggested, is like some men of genius whose work and contributions are felt long after the radiation of their genius has reached its maximum.

The next step of our gradual march through the year, takes us to the second equinox, the one that marks the beginning of autumn which occurs the 21st, 22nd, or 23rd of September (in 1934 on Sept. 23 at 11:46 P.M.), and sounds the knell of faltering summer. Then the sun, suspended as a disc of copper of the invisible and annual pendulum of which so few oscillations are sufficient to mark the duration of our life, passes again over the equator in its back and forth motion. And here again appears the thoughtlessness of our apparently civilized society. This date that should impassion the mature man passes unnoticed. No ceremony marks this event of silver-gilt autumn—spring of chrysanthemums. Only the poets in lines full of melancholy describe to us the sad falling of leaves and the departure of the swallows, although for every swallow that is exiled, hundreds of active sparrows are left with us, and the autumnal forest whose colors vary from the light amber to the blood red, deliver us from the monotonous verdure of the estival forest.

The day of the autumnal equinox that now passes unperceived will be perhaps sometime a universal festival day when the men in communion will celebrate the great natural phenomena which mark the eternal rhythm of the earth and Geolatrie will be throughout the world the religion of the state. Since the year is defined by the astronomers as the interval between two identical equinoxes, then the end of the year should coincide with the autumnal equinox which also marks the season in which the vegetable world completes its cycle. Yet, strange to say, not one of the calendars in use begins the new year at the equinox. The autumnal equinox is followed by the days of Indian summer the reality of which, although not quite scientifically proven, nevertheless evokes charming images of the last sparks of passing youth. And then, from the depths of December we see appearing the winter solstice and Christmas. The child

Jesus who comes to visit us with the reviving sun brings forth the ancient solar myths of Adonis, Horus, Dionysus and Mithra, that the poets of antiquity have sung in symbolic poems.

#### B. THE DAY

We come now to one of the most singular paradoxes that is presented to us by the annual sequence of the days. We know that the duration of the day is twenty-four hours, but this is a conventional day and is equal to the mean duration of all the days of the year. It was necessary to accept this convention which we will discuss at greater length later, because the sun, the true sun, has a very irregular and not at all constant East to West movement among the stars due to the variable distance of the earth from the sun and to other causes. On account of this it was found necessary to define the mean solar day as the time interval which separates two successive meridian passages of a fictive sun which would make, as the true sun, the round of the ecliptic in one year and would coincide with it at the equinox, but which would make this round in a uniform movement.

If we consider the true day, that is, the time that elapses between two successive passages of the true sun over the meridian, we observe that the duration of the true days is unequal and that the true day that coincides with the solstice of winter is the longest of all. Its duration is 28 seconds greater than the mean solar day, while the day coinciding with the equinoxes is smaller by twenty seconds. It is at least strange to say that the twenty-second of December, which is commonly considered the shortest day of the year, is in reality the longest.

The differences that exist between the time indicated by the true sun and the mean sun is much greater than is commonly imagined. For instance, in Paris the true noon coincides with the mean solar noon only four times each year; April 15th, June 15th, August 31st, and December 24th. During the remainder of the year the pendulum is either in advance or behind. For example, on February 12th, it is 14.5 minutes ahead and on November 3rd, it is retarded 16.5 minutes. In addition to the reasons mentioned above for the undesirability of the use of true time, we have other causes which make the abandonment of that time imperative. For centuries each town was using its local true time and that was not inconvenient in the time of stage coaches when men were irremediably moving within small circles, and in general were traveling little. The railroads, the

telegraphs and other inventions of rapid communication obliged nations to substitute in the place of local time a standard time for considerable geographical regions.

The earth was divided into 24 zones of  $15^{\circ}$  each by means of great circles passing through the poles, and the time of every point in the zone was determined by the mean hour of the central meridian. The initial zone on which all the others depend is the one that has as its central meridian that of Greenwich.

### C. THE HOUR

The day, the month, the seasons, and the year are natural divisions of time imposed on us in a certain measure by the phenomena themselves, by the diurnal course and the annual rhythm of the sun and the slowly changing periodicity of the moon. But, this is not true of the hour—nothing in the nature of things as they are presented to us does oblige us to divide the day into 24 hours. The hour is, therefore, a unit of time perfectly arbitrary in the same sense that the yard is an artificial unit of length which no physical cause has imposed to the exclusion of other units. Homer and Hesiod never distinguished more than two divisions in the day: the morning and the evening. According to *Zend-Avesta*, the ancient Persians distinguished but five periods: the time of aurora, which lasted from the middle of the night to sunrise; the time of sacrifice which extended to almost midday; the time of full light, from noon to sunset; the time between sunset until the appearance of the stars; and, finally, the time of the priest's evening prayers which extended until midnight. Much later, even, the Romans of the time of Terentius Varron did not divide the day into more than seven parts.

According to Bigourdan, the Accadians of ancient Chaldea subdivided the day and night each into 12 parts. This division was adopted by the Greeks and Romans and then later by the other civilized nations. Since the length of the day and night change constantly due to the seasons and to the latitude, and the length of the one increases at the expense of the other, the result is that the twelve parts of the day are sometimes longer and sometimes shorter than the twelve parts of the night. These parts were called temporary hours. In our latitude the diurnal temporary hours are almost twice as long in June as in December. The inverse is true for the nocturnal temporary hours in

December. The temporary hours are almost equal only near the equinoxes. In the fifteenth century they had to modify the clock every evening in order to divide the night into twelve equal parts, and then reverse the operation in the morning. Many centuries passed before equal hours for the day and the night, called equinoctial hours, were adopted.

The almanac of Regiomontanus (1436-1476) at the dawn of the Renaissance signalled the astronomical phenomena in terms of temporary hours. The invention of watches, because of their regular march, forced the people to substitute for the unequal temporary hours, the equinoctial hours of the same duration. Precisely an analogous cause, in the last analysis forced us in the measurement to time, to substitute an artificial and well regulated sun in the place of a real sun whose movements are irregular. Now, let us imagine a clock that is perfectly regular, that is, one whose parts are perfectly constructed and immune to any causes of variation, notably the ones due to variations of temperature and pressure. By means of such a clock, observing at a given place the time that elapses between two successive transits, we will notice that the time between two passages, that is, between two successive true noons, varies from one end of the year to the other as much as forty-eight seconds.

An ideal solar pendulum, in order to follow exactly the advance of the sun, should be able to go slower during the winter and faster at the equinoxes, an operation difficult to realize and adjust. It is true that the clocks for many centuries, even up to the last few years were not sufficiently precise in their movement to show small irregularities in the movement of the sun. That these irregularities were discovered a long time ago is due to observations of a clock much more perfect than the human clock, this being the starry vault of the sky.

The interval between two successive passages of a star over a given meridian is called the *sidereal* day. The sidereal day is shorter than the solar day because the apparent retrograde motion of the sun among the stars makes it seem that the sun appears to be rotating 365 times while the constellations appear to rotate 366 times a year. The sidereal day is therefore, about four minutes less than the average mean solar day. Sidereal time is used in regulating our pendulums, even the ones that indicate solar time. So, in the final analysis, the directing clock that we use to subdivide the time is in reality the terrestrial globe rotating on its axis with respect to the far away stars.

## D. THE DETERMINATION OF TIME

Occasionally, astronomers, physicists, chronometrists, and watchmakers meet in great numbers to discuss the problems that are placed before us by the inordinate flow of time and there are scarcely more impassionating problems for the philosopher and the savant.

It is not the time considered from the philosophical point of view that they consider in these chronometric congresses. Prosaically, but more usefully, they are concerned with theoretical and practical questions which rise with the problems of determination, conservation and transmission of time. It is not only sufficient to define exactly the units of time, it is equally important to know how to determine it, how to conserve it, and then distribute it among the people that need it, that is, almost throughout the earth.

In the past the hour was determined by the method of heights. This method consisted in observing the sun with a telescope at a given moment of the morning and in marking on a graduated circle its height above the equator and reading the time on a nearby clock. Then, in the afternoon when the sun has reached the same height, the corresponding time was again read. It is clear that the middle of the two time readings so determined on the pendulum corresponds to the true noon. A concrete example will make this method clearer. Suppose, for instance, that the time of the first observation was 11 hours and 3 minutes, and the second observation was at 13 hours, and 5 minutes. The true noon, therefore, was at 12 hours and 4 minutes, which means that our clock was four minutes in advance. This method was used up to the time that Roemer invented his meridian circle, an instrument similar to the transit instrument.

It has been observed that the determination of time is much more accurate when the observations are made with the stars whose images are points, instead of the sun. Ordinarily, certain stars called fundamental stars, whose positions are well known with respect to the sun, are utilized for meridian observations. From these observations solar time is easily derived.

At this point we may remark that even the best observers habitually note the passage of a star across the fixed wires of the reticle slightly too late or a little too early, by an amount which is different for each observer. This error, though it varies, usually less than 0.1 of a second for chronographic ob-

servations, is an extremely troublesome error, because it varies with the observer's physical condition and also with the nature and brightness of the object. Faint stars are almost always observed too late, in comparison with bright ones, and this gives rise to the so-called magnitude equation. The effect of personal equations has been very greatly diminished by the introduction of the transit micrometer. The relative personal equations of observers, after a little practice with this apparatus, becomes almost vanishingly small and are almost independent of the brightness of the stars observed. With these instruments it is possible to determine time with an accuracy of one one-hundredth of a second and it is rather difficult to hope for an increase in precision. At this point we are limited not by instrumental difficulties, but by the continuous undulations and movements of the atmosphere which renders trembling and imperfectly uniform the passage of the star through the telescope.

#### E. THE PRESERVATION OF TIME

Now, the time that has been determined with such precision must be conserved and this is the function of clocks and chronometers. In Rome the opulent patricians had a slave especially charged with bringing the hour from the sun dial that was in the public square. Later, in order to limit the long speeches of politicians, another instrument was invented, the clepsydra, a contrivance for measuring time by the graduated flow of a liquid, such as water, through a small aperture. Ancient authors report to us that the servant in charge of the clepsydra used to favor their friends and obstruct their adversaries by increasing or decreasing the size of the aperture by means of ingeniously concealed wax. It seems that from this standpoint, our political morals have improved! And now, omitting names and instruments of secondary importance, we come to the great pioneer and hero of the technique of conservation of time, the Dutch citizen, Huyghens, who was called to Paris by the intelligent eclectism of Louis XIV, for whom nationalistic barriers in the realm of knowledge and talent did not exist.

Huyghens performed, in Paris, most of his experiments and was the savant whose works advanced more than that of any other the art of conservation of time.

He invented the pendulum clock, concerning which he published the first communication in 1667. It was astonishing how thoroughly he developed this means of measuring time, which

is today quite general. His work was almost exhaustive, and developed the clock in all essentials in the form in use at present. In his famous work, *Horologium Oscillatorium*, which appeared in 1673, was included a mass of experimental results that went far beyond the actual subject. His pendulum clock suddenly raised the measurement of time, both in science and in daily life, to a quite new level of refinement, which up to that time had been striven for in vain, and was scarcely imagined to be possible.

It is true that clocks with hands and trains of wheels driven by weights had long been in existence, but they were irregular and unreliable since they were regulated by frictional resistance which is variable.

Instead of controlling the motion by friction which is subject to variation, he used the pendulum which possesses its own controlling force in its invariable weight, and hence a fixed period of oscillations, which are uninfluenced by the power of the train, the latter being needed only to overcome the air friction of the pendulum.

For navigation, good clocks were, and are, of the greatest importance for the trustworthy determination of geographical distances, and the correct measurement of position at sea. But in this case the usual pendulum, dependent upon gravity, was not satisfactory in spite of Huyghen's special effort, on account of the oscillations of the ship. He used elastically controlled pendulums for these clocks, such as we still find today in the escapements of pocket watches and ships' chronometers. The introduction of this essential feature of accurate running was the point of novelty since pocket watches with trains of wheels driven by springs, existed already and were known on account of their external form and point of origin as "Nuremberg Eggs."

In summing up the mechanical clocks since the time of Huyghens, we find that they all consist of three essential parts, (1) the motor, weights or spring, or lately electricity, (2) the regulator or oscillating pendulum, (3) the escapement.

Causes affecting the accuracy of a pendulum are changes in temperature and barometric pressure. The length of the rod of the oscillating pendulum changes with varying temperature and various compensating systems were invented to offset this difficulty. The oldest and still best is that of Graham which consists of the attachment of a tube containing mercury at the

bottom of the pendulum. With increasing or decreasing temperature the position of the center of gravity of the pendulum and of the mercurial column changes. It is easy to calculate the relative dimensions of the metallic pendulum and of the mercurial mass so that the elevation of the center of gravity of the mercury is exactly compensated by the lowering of the center of gravity of the pendulum. The best of all materials for a pendulum is invar, a nickel-steel alloy whose coefficient of expansion is vanishingly small.

The changes of barometric pressure have a perturbing effect. At first, they thought of compensating pressure but finally it was found that if great precision was necessary it would be more effective to eliminate completely changes of temperature and pressure by inclosing the clocks in thermally insulated boxes. This process which now has found general application constitutes the latest improvement in the astronomical clocks, and makes available precisions which a few years ago were unknown.

With respect to the service of the conservation of time, it seems that the observatory of Paris has attained enviable perfection. Four pendulums, masterpieces of precision to which astronomical time is reported, are placed in a closed vault 82 feet below the level of the observatory. Thanks to this arrangement the pendulums remain at perfectly constant temperatures throughout the year. This is due to the fact that, while on the surface of the ground the temperature follows the vicissitudes of the atmospheric changes of temperature, these changes become less and less important with increasing depth, and at about 60 feet below the surface, a region of constant temperature is reached. These clocks are also inclosed in air-tight compartments so that the atmospheric pressure variations are completely eliminated. At this point we may remember that no one approaches these precious machines, for they are electrically wound and electrically transmit the time to the other pendulums of the observatory and then by wireless to distant points throughout the earth.

One may ask why four pendulums and not only one? This is in order that they might be mutually supervised and controlled so that any accidental variation of one can be immediately signalled by the others. The most remarkable of these four clocks is probably the one designated as 1228L. This clock has been running now for several years without pause or cleaning

and has not varied more than 1 to 2 hundredths of a second in any 48 hours.

In connection with clocks of precision and especially with pendulum clocks, by *correction* we mean the difference between the time that the clock indicates and the time that it should indicate. The *correction* is plus when the clock is slow and minus when fast. By the *rate* of a clock is meant the daily change in its correction: it is plus (+) when the clock is losing and minus (-) when it is gaining. A good clock has a constant rate. The rate is adjusted by raising or lowering the center of gravity of the pendulum, or for finer adjustment, by altering the pressure within the air-tight clock case.

Before the perfection of clocks, the astronomer was looking after the pendulum and was always correcting it by celestial observations, but today it is often the pendulum that corrects the astronomer and rectifies his results. At any rate, when on account of bad weather, it is impossible to make astronomical observations of the time, it is not a great inconvenience any more, for the directing clocks are there and their marvelously regular hands supplement the absent stars. However, we must not exaggerate, for in the long run, the astronomer has the last word, because his observations are based on the perfect regularity of diurnal movement, while the most perfect existing pendulum does not conserve the same rate, and at the end of 10 or 1000 days the telescope will always give the time with a precision of two hundredths of a second while the clocks will give it with a precision which diminishes in proportion to the time.

#### F. THE DISTRIBUTION OF TIME

Now the time which has been determined and conserved with such precision would have been a useless luxury and a curiosity without any other attribute than the overcoming of difficulties, if we were satisfied to keep it in the observatories. No less important than the determination of time is its *distribution* to the agencies that need it; for example, public administrations, railroads, navigators, geographers and other scientists. The navigators must at every moment know the exact reference hour which all nations accepted to be that of Greenwich.

Up to the beginning of this century navigators had only one method of meeting this problem: that was, to bring with them the hour of the reference meridian. For that purpose they needed a chronometer having a very regular rate which had to

be adjusted at the moment of departure, and it was indispensable that they be very reliable especially in the case of a very long trip. Small chronometric deviations involve considerable errors in the estimation of position. On the equator every second of error corresponds to a geographic deviation of about 1,500 feet and every minute to more than eighteen miles. Thanks to the radio the nature of the problem of longitude has completely changed; it is no longer a problem of conservation, but of distribution of time. The precise chronometer loses its importance and becomes almost unnecessary, thanks to Hertzian waves that carry the message of correct time around the world in about one-seventh of a second.

At this point we will give a brief historical review of the methods used in the distribution of time in the three nations which, on account of their scientific and commercial interests, played an important pioneering role in solving the problem of distribution of time.

In the United States, in August, 1865, the Naval Observatory at Washington, D. C., began sending signals daily at 7:00 P.M., 12:00 noon, and 6:00 A.M. to the police and fire alarm stations of the Capital and to the Western Union Company for transmission to the company's offices throughout the United States. This was the beginning of the present elaborate system of the hourly distribution of the Naval Observatory Time by Western Union, which, since May, 1877, has been distributing the Naval Observatory Time to all cities in the United States which have a population of more than twenty thousand. Later, this privilege of obtaining Observatory Time was extended to all companies willing to undertake its distribution at their own expense.

In 1880, the Naval Observatory began sending time signals automatically instead of by hand, and by 1883 clocks automatically controlled by the Naval Observatory clock were in use at the various government departments. During the same year the continent was divided into five belts, and a meridian of time was fixed for each belt. These belts begin with the sixtieth meridian west of Greenwich and the time difference between successive zones is one hour. In the far east, the Manila Observatory, with the cooperation of the naval station at Cavite began furnishing time daily since April 1, 1903.

The first signal by radio was sent on August 9, 1904, at the Navy Yard of Boston, and by the end of that year, time signals were also sent by the naval station at Cape Cod and Norfolk.

The Naval Observatory, in 1905, was the first institution to undertake the transmission of time to ships.

In 1909, the number of time-signal sending stations was nineteen, and their range was about a hundred miles. However, with increasing range of transmission, the number of stations in 1913 was reduced to that of Arlington, Key West, and New Orleans in the East, and Mau Island, California, in the West. On March 13, 1913 the Arlington station began sending signals between 9:55 P.M. and 10:00 P.M. and later at noon also.

The number of naval stations in 1925 in the United States, Panama, and the Philippines has increased to thirteen.

At present, due to the cooperation of various naval stations, time signals originating at the Naval Observatory at Washington can be heard all over the world.

In England the master mean-time pendulum at the Greenwich Observatory sends a time signal once a day to the General Postoffice. It also sends signals to the British Broadcasting Corporation at the last six second beat of each quarter hour and half hour. The service of the distribution of time throughout the Isles is organized as follows. By means of automatic switches, a number of telegraph lines from the General Postoffice in St. Martin's-le-Grande to provincial towns and certain lines from these towns to smaller offices, are, just before 10:00 A.M. disconnected from the telegraph instruments and joined through to Greenwich for the reception of the time signal. From these smaller offices the lines are extended to the time subscribers, so that the 10:00 A.M. signal from the Greenwich mean-time clock is distributed throughout the country.

The mean-time master clock also controls a special pendulum which sends out the Rugby time signals. These signals are intended for the use of navigators and explorers who need to know the accurate Greenwich time in order to determine their longitude.

It is hoped that in the near future, it will be possible to broadcast the time every hour instead of once a day, and that ultimately the beats of the pendulum of the Greenwich mean-time clock may be broadcasted continuously so that at any time and at any place a comparison with the standard clock at Greenwich may be made.

In France, on the twenty-second of June, 1910, the Bureau of Longitude of France under the presidency of Henri Poincare

inaugurated the hourly time service of Eiffel Tower and since then the time service has not been interrupted for a single day. The Hertzian distribution of time by the Eiffel Tower was crowned with such a success that the Bureau des Longitudes invited an international congress to discuss the means and methods of improvement and extension of the services. The congress met in Paris from the twentieth to twenty-fifth of October, 1913, and thirty nations were represented. It was decided that a number of existing stations and others to be constructed around the world should broadcast every day at a definite moment the Greenwich time. This would enable explorers, navigators, and geographers wherever they might be to receive the correct time. These signals quite often are utilized by cartographic expeditions in connection with the fixing of boundaries in distant colonies such as Morocco, the Congo, and Cameroon. Two powerful stations at Tchad and Madagascar send the messages across the African continent.

Whenever great precision in connection with the reception of time is not required, the old-fashioned eye-and-ear method is utilized. It simply consists in noting with the eye the position of the hands of the pendulum when the ear perceives the time signals. The time by this method can be estimated by an experienced observer within one-tenth of a second. In the physics laboratories observations of this method are generally substituted by automatic recordings.

In addition to the ordinary time signals we have the scientific signals whose precision is about five times greater. The time so obtained has a precision of one-fiftieth of a second. This method of signalling is known as "the method of coincidence" and is analogous in the measure of time to the vernier caliper in connection with the measurement of length.

#### G. THE CALENDAR REFORM

After the above delineation of the problems of the determination, conservation, and distribution of time, we must add a few words in connection with another time problem of perhaps greater direct importance to the everyday life of the average man than the extreme scientific precision of the determination of time. This problem deals with the desirability and practicability in introducing reforms in the calendric year at present in use. We will not go through the history of the vicissitudes of the evolution of the calendar now in use, which are well known,

but we will simply mention some of the most promising possible solutions of the problem. These suggestions have been made through various agencies, but especially through the League of Nations.

One of these propositions, the one to which was awarded the first prize of the French Astronomical Society, was submitted by Armelin. He proposed the adoption of equal quarters each consisting of ninety-one days divided into two months of thirty days and one of thirty-one. This makes a year of 364 days to which is added one supplementary day or two in the case of a bisectial year. The supplementary days are not dated so that every quarter consists of thirteen whole weeks, and in the quarter the same dates correspond always to the same days for a given week of the quarter.

Searle, an American astronomer, proposed a year consisting of fifty-two weeks and a fifty-third week interposed every seventh year and made up of the accumulated days. The Delaporte reform consists of a year composed of 364 days with one or two additional days without dates, but instead of the quarters, to have the week as a fundamental unit. The year would consist of thirteen months of twenty-eight days each ( $13 \times 28 = 364$ ), and each month would consist of four weeks of seven days each. In this system the same date will correspond to the same day of the week and all the months will be of equal duration.

In the United States the thirteen-month plan found in the late George Eastman its greatest sponsor. He subsidized it as the International Fixed Calendar Plan, and since his death the University of Rochester has continued to support this rigorously logical plan. In fact, on account of its obvious logical advantages this plan is utilized by about seven hundred houses for their own accounting purposes. Among these are included such companies as Sears-Roebuck, Hearst Publications, Time Inc., etc.

We have said that this year is rigorously logical; but its greatest disadvantage is the offense to our secular habits of twelve months. Will the public accept a year of thirteen months? Many people will not like to embark upon an enterprise the thirteenth month, and it will require superhuman indifference to superstition to begin anything, however trivial, on Friday, the thirteenth of the thirteenth month.

Another drawback of this perfectly logical calendar in addition to that of superstition, is the disorientation that is

introduced in the commercial world on account of the elimination of the very convenient subdivisions of semesters and quarters.

It seems that this is a very serious objection and the First International Congress for the Reform of the Calendar that met a number of years ago at Liege decided in favor of a twelve-month year. At the present time it seems that the general opinion, scientific and otherwise, is crystallizing in favor of Armelin's calendar of 364 days with one or two days without dates added according to the case.

The year 1935 was to have been an important year for the calendar reformers. Scientists were to take up the two major recommendations—the thirteen-month year and the equal-quarter year—in connection with the League of Nations. Latest advices from Geneva, however, indicate that nothing will be done before 1936. Eventually the League will recommend an authorized international conference similar to the one called by the United States fifty years ago to adopt international standard time.

In any case, one thing is certain, that in the reform of the calendar we must not insist on too much scientific precision. One must have in mind that this reform is mainly imposed because of commercial and practical reasons and that only with the help of the commercial world which begins to understand the advantages of the proposed changes can an early reform be contemplated.

There is wisdom in not expecting absolute perfection in man or nature. One of the most singular errors of that divine dreamer, Plato, was to expect simple relationships in nature and perfection in the order of things. The history of civilization teaches us how impractical were his idealistic expectations. The truth is that the real and profound harmonies of the world are not subject to the pitiful rules of our logic, and as Fresnel justly said, "Nature does not worry about our analytical difficulties."

And now, after this study of the time units which we call years, hours, minutes, seconds, and which we are incapable of exactly defining except for an infinitesimal of the life of the universe one may ask us what moral law or conclusion may be derived from the study of this physical concept with which our own existence is hopelessly and inextricably united? The answer to this question is difficult and transcends the domain of physics,

but involuntarily we think of the Latin poet who said, "Live as though you were to die tomorrow," or of the more energetic variation, "Think as though you were to die tomorrow and act as though you were to live forever."

## A METHOD OF TEACHING EQUATION WRITING

BY CHARLES H. STONE

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The importance of the equation in any course in chemistry is obvious. The ability to write chemical equations correctly is of the first importance, but is often acquired by the beginner only with difficulty and after continued practice. Too often the method of presentation is uninteresting and dry and the student comes to regard equations as a necessary evil and a bug-bear. But the subject can be presented in such a way as to become interesting to the student, instead of unattractive.

The writer has used the method described below for a number of years with good results.

Arrange upon the lecture desk a dozen or more 50 cc graduates and fill each about half full of water. Behind each graduate place two bottles containing solutions of reagents which, when mixed, will produce a precipitate. For example, the first pair of bottles might contain silver nitrate and hydrochloric acid. The bottles should be arranged in such order that the successive equations will increase in difficulty but not too rapidly. The following pairs of reagents may be used:

Mercurous nitrate and potassium iodide  
Silver nitrate and sodium chloride  
Silver nitrate and potassium iodide  
Copper sulphate and sodium carbonate  
Barium chloride and zinc sulphate  
Lead nitrate and potassium iodide  
Mercuric chloride and potassium iodide  
Lead nitrate and potassium chromate

Many other combinations will suggest themselves to the interested teacher. Such difficult combinations as ferric chloride and potassium ferrocyanide, and aluminium sulphate and barium chloride should be deferred until the students have acquired a considerable mastery of the simpler equations.

When all is ready, the teacher may explain briefly the method of procedure and then call Johnny down to the desk to perform the first experiment. He pours together into the first graduate silver nitrate and potassium chromate, let us say. A red precipitate is formed. He is then asked to write the equation on the blackboard, the teacher making needful suggestions at first. Then comes up the question of color. From the equation it is apparent that two products are formed, silver chromate and potassium nitrate. Which one of these is the red one? At this point the teacher may put forward a bottle containing solid potassium nitrate and ask the class to note the color of it and then to draw their conclusions. At once they will arrive at the conclusion that the red precipitate must be silver chromate. The color is then indicated on the board by writing the word "Red" above or after the formula for the silver chromate. Johnny then sits down and Jennie is called to the desk and the process repeated with the next pair of solutions. Since a little skill in arranging the pairs of bottles will prevent the continued recurrence of the same color, the class is kept in the expectant attitude since they can not guess what the next color will be.

With the more difficult equations, such as the reactions between the chlorides of arsenic and antimony with hydrogen sulphide, the question of coefficients will of course come up. A spirited class discussion may be started and the question threshed out to the satisfaction of the students.

Some surprising things may be introduced to heighten the interest. For example, the reaction between a little lead nitrate and hydrogen sulphide produces a black precipitate. Addition of hydrogen peroxide will change this to white lead sulphate by oxidation. The pink precipitate formed by potassium iodide and mercuric chloride will disappear if more potassium iodide is added, as will, also, the white precipitate formed by the action of sodium hydroxide on soluble lead salts when more sodium hydroxide is added, the plumbite being formed.

This series of experiments can be continued through several recitations at the teacher's option, gradually leading up to the more difficult equations for reactions in solution. The class exercises should be supplemented by similar exercises in the laboratory. It is not unusual in the laboratory to hear some student remark: "Gee! This is the most interesting experiment yet!"

## FACTORS CONDITIONING THE DEVELOPMENT OF UNDERSTANDINGS IN BEGINNING SCIENCE\*

BY GERALDINE SHONTZ

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There is an increasing belief that the science program of the public schools should be built as a whole, and that the curriculum should include the scientific principles and concepts necessary to its development. Such lists of principles and concepts as the one compiled by the Committee in Chapter IV of the Thirty-First Yearbook, National Society for the Study of Education, have provided the basis on which to build a program of science instruction. These lists will be augmented and revised as further experimentation reveals new implications and as new science developments reveal significant truths. The development of each basic principle or concept requires certain understandings some of which are extremely simple while some are exceedingly intricate. Thus it becomes necessary to allocate principles, concepts, and understandings to the various school levels. Some understandings have intrinsic value to young children and are simple enough to be introduced at an early age. Their development in the lower grades is conditioned by several factors, (1) the difficulties which have to do with grade placement, (2) the philosophy and background of the teacher, (3) superstitions and unscientific beliefs which are traditional in many families and localities, (4) animistic treatment of science materials, and (5) the lack of sufficient suitable references.

### I. DIFFICULTIES OF GRADE PLACEMENT

Little experimentation has been reported on the development of understandings in the lower grades. The writer's experience leads her to the following conclusions.

- A. The understandings must admit of being stated simply.
- B. There must be opportunity for providing experiences through which understandings may be developed.
- C. The understanding must be simple enough for comprehension and yet difficult enough to challenge the interest of children of the particular age level.

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D. Certain understandings can be developed completely while only the simplest beginnings are possible with others.

For example, in developing understandings relative to plant growth the understanding, a green plant needs light for growth is simple enough for first grade children to comprehend. Experience in this case, may be provided for its development through experimentation. The children may try to grow plants in direct sunlight, in diffused light and in the dark. The writer has found this to be a profitable method of developing this particular understanding. The number of experiments which the children carried on independently at home indicated that the understanding was challenging in its implication and that it was not unduly difficult.

That green plants require light for growth is in itself a complete understanding. It is, also, basic to the concept "photosynthesis." It is evident that other more difficult understandings must be developed in higher grades before the children will know the process by which plants manufacture their food.

The allocation of understandings depends on their difficulty and on the units in the science program. Until further investigations are made regarding understandings they will continue to be a conditioning factor.

## II. PHILOSOPHY AND BACKGROUND OF THE TEACHER

- A. The teacher need not be a specialist but she should have a fairly adequate background and an interest in working with children and their science problems.
- B. The teacher should be acquainted with reputable science authorities and should have at hand source material which will take care of immediate problems. *Comstock's Handbook of Nature Study*, *Compton's Encyclopedia* and the *Classroom Teacher*, Vol. 10 are types of material which will serve this purpose.
- C. The teacher should know the science curriculum as a whole in order that she may appreciate the significance of her part in the science program.
- D. The teacher should be able to select the subject matter content through which understandings may be most profitably developed.
- E. The teacher should recognize the value of available materials.
- F. The teacher should know how to show appreciation of the

contributions which the children bring and should know how to use them to advantage.

- G. The teacher should have such a knowledge of child development that she will be tolerant of interpretations and reactions which result from their limited experience.

Without a doubt, science supervisors and teachers are in accord with these reactions concerning the philosophy and background of the teacher. The writer has been impressed with the importance of the last two items as conditioning factors in developing both attitudes and understandings. For example, last summer this incident happened. The first grade children brought to school on a certain date the plants with which they had experimented. John who was ill at the time brought his plant a day or two late. Unfortunately it failed to come to the attention of the science teacher until his mother reported the omission to her. It seemed that John's interest in school began to lag after his illness. When the mother tried to discover the reason she found that John's plant was the source of the difficulty. He had failed to receive the satisfaction which he had expected from showing his plant to his teacher and classmates. The result was that he was losing interest not only in science but in his other school work. Fortunately in this case the mistake was rectified. While similar incidents could be cited this one is sufficient to illustrate the problem.

The second item has to do with children's difficulty in interpretation. These difficulties furnish us many a hearty laugh but the implications are not so humorous. A four-year-old child, who was looking at the ocean for the first time asked the question, "Is there a plug under it?" She had grown up in an environment of pavements and bath tubs and her question showed the result of her limited experience. A teacher who would help the child to build a more adequate meaning for ocean would need to recognize this limitation. Too often teachers forget that children interpret through their own background and not through the teacher's.

### III. SUPERSTITIONS AND UNSCIENTIFIC BELIEFS

The development of understandings is often hindered by the superstitions and unscientific beliefs which are traditional in many families and localities. Experience in dealing with this problem leads the writer to make the following suggestions.

- A. Compile a list of local superstitions and unscientific beliefs.

- B. When planning any science unit consult this list and make provisions for dealing with these superstitions or unscientific beliefs which would interfere with understandings and concepts.
- C. Recognize the fact that it is difficult for children to give up family traditions even when they have proved that the superstition is false.
- D. Help children to recognize the ear marks of superstitions and to take pride in discovering truths, while maintaining a tolerant attitude toward those who have not had the opportunity of developing scientific attitudes.

One of the particular superstitions of the locality in which I teach is that of the horse hair snake. About four years ago a fourth grade child brought to school a "horse hair snake." She exhibited it proudly and told the class that her grandmother said it had developed from a hair of a horse's tail. She was given material to enable her to find out the truth regarding the worm, and soon discovered the mistake in regard to it. Almost every year since that time one of these worms has been on exhibit in the science room. Just the other day this child now an eighth grader recalled her story of the horse hair snake to a group of classmates. When the children corrected her, she said, "I guess I never will realize where a horse hair snake really comes from."

The teacher can do much to encourage children to take pride in breaking down superstitious beliefs and fallacies. But she must not forget to help them to be tolerant toward those who have not had the opportunity to secure scientific information.

#### IV. ANIMISTIC TREATMENT OF SCIENCE MATERIALS

One of the fallacies which causes difficulties in developing understandings is a mistaken notion of what is easy and interesting to children. The animistic treatment of living things and of natural phenomena is a result of this misconception. The writer offers these suggestions.

- A. The lower grade teacher should have in mind the end to be accomplished in the concepts which she begins.
- B. The teacher should recognize the fact that it is easier for the child to have correct meanings developed rather than to learn incorrect ones which must be retaught within a short period.
- C. The teacher should recognize the fact that legends and

myths do not contribute to scientific information, and that they are confusing to children who are trying to secure scientific information.

- D. The teacher should recognize the value of literature in developing appreciation in the upper grades after the children have developed the necessary understandings.

It is the responsibility of the lower grade teacher to help children to learn to identify certain of the common birds, flowers and trees. If the teacher helps the children to learn the items necessary in identification, they have a tool which will be useful as long as they are interested. If instead, the children use the animistic terminology found in many of the lower grade readers, each item must be relearned when needed. For example, the woodpecker's neck tie is far from being an accurate description of a marking which would help to identify a woodpecker. Nor is the flower's pink dress a help in identifying a rose. Thus the animistic treatment fails to help the child in securing a tool for which he would have later use.

#### V. THE LACK OF SUFFICIENT SUITABLE REFERENCES

This factor limits the development of understandings largely to experimentation and oral instruction. Good material is becoming increasingly available. Through its use children are able to develop some understandings independently. There is need for material which complies with the following criteria.

- A. Simple information with accurate detail sufficient in quantity to help the child develop the understanding which he needs.
- B. Informational material which will answer children's questions.
- C. Authentic illustrations which will contribute to understandings.
- D. Adequate table of contents and index to facilitate the use of the text.

There are many other factors which are worthy of consideration by those who teach beginning science if they are interested in building the understandings necessary to an adequate science program. The writer hopes that those who have had experience in dealing with the conditioning factors set up in this paper will contribute from their experience in order that we as teachers of science may have well developed understandings on our level. With this foundation we should be able to guide those who are making a beginning in the field of science.

## THE MATHEMATICS AND SCIENCE BEHIND AIR CONDITIONING\*

BY ROY M. MOFFITT,

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When Mark Twain commented that "everyone talked about the weather but no one ever did anything about it" he made a most prophetic challenge for air conditioning.

Air Conditioning! No euphonious morsel has ever pleased an ear or stimulated an imagination more since the first automobile chugged its way down Main Street.

So great has been the appeal of the phrase "Air Conditioning" that literally thousands have rushed into the *industry* before even inquiring into the most fundamental principles of its foundation. Thus today we have an intensely interesting, extremely complex, and highly technical industrial prodigy rapidly developing, in spite of the well-meaning meddling of sundry barbers, shoe-makers, realtors, and believe it or not, undertakers.

That we may start on a firm foundation let us first define this thing called "Air Conditioning." It is the "*simultaneous control* of temperature, humidity, air motion and air distribution within an enclosure. Where human health and comfort are involved, a reasonable air purity is included." Ionization is another factor that is now being given much thought. It should be especially noted that air conditioning is the *simultaneous control* of these functions, and is not the functions themselves.

Industrial applications of controlled temperature, humidity, air motion and air distribution in certain processes have long been used. The modern bakery can produce a uniform loaf from hour to hour and day to day only by minutely and accurately controlled air conditions. Offset printing, to insure accurate register of colors, must employ air conditioning. The entire textile industry would be helpless without it. Modern telephone cables would be so much scrap copper, lead and paper were they made in a space not subject to accurate control of extreme air temperatures and humidity conditions.

The characteristic feature of air conditioning for industry is the accuracy of control within very narrow limits. These are

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\* An address before the 34th Annual Convention of the Central Association of Science and Mathematics Teachers, Indianapolis, Dec. 1, 1934.

the very characteristics that do not appear in air conditioning as now popularly accepted—that is, for human comfort.

That there may be no misunderstanding of the importance of this new factor in the affairs of men, let us examine our architecture. Our first buildings were conceived with but one purpose in mind. That purpose was *shelter*. Down through the ages, from the original thatched hut to the ornate, glorified, and sometimes monumental skyscraper, that sole purpose of shelter prevails. It is not unusual, then, that men should feel the importance of an instrumentality which would transform an inherently prehistoric shelter into a modern utility of health, comfort, and pleasure, although they do not necessarily understand anything about the instrumentality itself. The result has been many divergent ideas, methods, and short-lived panaceas called "Air Conditioners."

Since conditioning is to be for human comfort, we may as well determine when a human is comfortable and why. It is a well known fact that two people, however harmonious their lives, however deep their understanding, and however mutual their interests, can nevertheless seldom agree on how warm is hot and how cool is cold. That premise alone indicates how very complex must be the formula for solving the world's most popular controversy.

Each human has his own comfort controlling functions. If he is too cold his digestive functions accelerate, oxidation is stimulated and more heat is supplied to the body. If he becomes extremely cold an involuntary reaction takes place, he shivers and his heating facilities commence to work at an overload—and the subject gets warmer. If he is too warm he perspires freely, and the evaporation from his skin truly converts the entire surface of his body into an effective refrigerating function and he gets cooler—*provided* the air in which he is living is not too dry when he is cold or too wet when he is warm.

So the age-old controversy as to whether it is or is not comfortable in the old family sitting room resolves itself into a coordination of several related scientific and mathematical analyses: *First*, the rate of heat generation in the respective subjects, which brings up dietetics and physiology. *Second*, the rate of heat dissipation from each of the participants in the family discussion, which calls for a knowledge of anatomy and a touch of thermo-dynamics. *Third*, the temperature of the air,

the vapor pressures at the skin surfaces and of the air; more thermo-dynamics and a smattering of physics.

Nor have we more than begun to analyze the controversy of comfort. Let us look at the effects of heat on the various proportions of air and water vapor mixtures as regards human comfort. Effective temperature is a numerical index only. It has no constant relation to either wet or dry bulb temperatures. It is but an empirical index to the human comfort afforded by still air of the varying qualities. When the air is placed in motion over the human subject the effective temperature line not only changes to a lower index but also changes its curvature. This again emphasizes the empirical nature of the very object of air conditioning as it interests the popular mind.

It is the *control* of these factors—dry bulb and wet bulb temperatures and air motion—that constitutes the most fascinating of all scientific and mathematical pursuits. Fascinating because of the many possible and really few satisfactory combinations of physical and physiological variables which enter into the problem.

Arriving at a condition of air which will produce comfort to the maximum number of occupants in a space is much a matter of painstaking detail. The thermal loss under maximum temperature difference is computed as has been done since way back when the steam radiator was supplanting the pipe coils for heating. Also the thermal gain is similarly computed, but with much greater care.

Loads or gains, due to direct radiation of Solar energy, are meticulously calculated. This involves not only period of exposure but angle of solar deflection, mass of and thermal values of the structure and the lag between maximum exposure and maximum effect on the air within the structure.

It is obvious that the sun cannot shine on both east and west sides of a house at the same time. What is not so obvious is that the solar effect on the east side of a building may in early afternoon be as great or greater than on the west side of the same building at the same time.

In a physiological laboratory a year or so ago, the requirements were 75 degrees dry bulb at 50% relative humidity constantly maintained, with allowable variations of 1 degree and 2%. To maintain such conditions required facilities for cooling the west side of the building on an autumn afternoon and at the same time heating rooms on the opposite side of the building.

The internal heat gains, both sensible and latent, are also carefully calculated—population, human load at rest, at normal exercise or at violent labor; illumination, and all other internal sources of heat are calculated.

These internal loads are frequently very interesting. Generally it is found that a theater fully occupied has a greater internal heat gain than the structural losses under extreme temperature differences, and were it not for the ventilation or fresh air requirements for the occupants, no heating equipment would be needed to maintain a comfortable temperature. Which brings us to the most trying of all cooling loads—fresh air.

Building codes written when base burners were accepted in polite society still prevail, although that well known carbon monoxide generator has long been taboo. These antiquated codes, based on hazardous equipment and not on human health or comfort, require from twenty-five to thirty cubic feet of new air, fresh air, or make-up air, as you choose, per person per minute. Scientific tests indicate ten cubic feet per minute per person to be adequate not only for human health and comfort, but to dissipate all trace of objectionable odors. So-called fresh air obviously must be conditioned before introduction into the treated space.

The old saw about "It isn't the heat, it's the humidity" well emphasizes the necessity and importance of removing much latent heat from fresh air when the outdoor wet bulb temperature is high, which is a costly process both from original equipment investment and operating expense. Or, when the heating function is operative, the addition of sensible and latent heat to the same quantities of air.

When, as, and if any of you have to do with the revision or making of ventilating codes, the undying gratitude of a struggling industry will be yours for but some small deduction from the normal fresh or new or make-up-air requirements when adequate air conditioning facilities are provided.

The adding of humidity to air being heated is a simple process of passing the air through water sprays. The *control* is not so simple. Because of a varying dry bulb temperature and the inaccuracy of stationary wet bulb thermostats, a direct control of the spray is not feasible. Four methods are employed in the control of humidity or wet bulb temperature: *First*, the direct acting humidistat. This instrument depends upon the expansion and contraction of an hygroscopic element which actuates an

electrical switch controlling the spray volume. A *second* method employs a differential wet bulb and dry bulb thermostat controlling the volume of spray water. A *third* method is a wet and dry bulb thermostatic control of spray water temperature, and *the last* consists of a pre-cooler, reducing the air to the pre-determined dew point temperature, saturating at this point and reheating to the required final temperature.

The accuracy of these controls is in the order named. Humidistat least accurate—5% to 10% relative humidity. Wet and dry bulb thermostat 4% to 8%; spray water temperature control 2% to 3%, and dew point control 1% to 2%. First cost recommends the humidistat method, and good judgment recommends the spray water temperature method.

The heating functions of air conditioning are not materially different in mathematical aspects from normal heating practice. The same fundamental formulae of design, capacity and operation of boilers, heat exchangers and piping apply.

With dehumidifying and cooling equipment, however, it is a vastly different story. Dehumidifying has long been accepted as a by-process with cooling, and this is the method most generally used today. There are now two other methods in development, however, which are more chemical than physical in their nature. Absorption and adsorption of water vapor from air has been receiving much attention in industrial laboratories. There are many possibilities to the chemical aspect of dehumidification, which in a large part of our temperate zone may be the ultimate answer to an effective and economical means of comfort conditioning. A study of the relative vapor pressures of air at 75 degrees wet bulb and varying concentrations of calcium chloride solutions and the resultant effect of each to the other will demonstrate one place where the chemist may start toward getting his name in *Who's Who*, and an honorable mention by *Dunn and Bradstreet*.

The development of refrigerants during the past few years seems to have been the principal focal point for the chemist. Time was, not so long ago, that  $\text{NH}_3$  and  $\text{CO}_2$  were the accepted refrigerants. Then came Sulphur Dioxide, Methyl Chloride, and now that remarkable achievement of molecular gymnastics—Dichlorodifluoromethane, or F-12 for short. This molecule was juggled into being by a series of laboratory reorganizations of carbon tetrachloride, until recently used principally for fire extinguishers and dry cleaning. When as much thought and

time is devoted to hygroscopic salts for dehumidifying as has been given to carbona for cooling, it is a fair forecast that many of us who now look on air conditioning as a very expensive luxury will consider it in exactly the same light as we now look upon a pair of shoes. Nor is chemistry the only background for cooling and dehumidifying

The cycle of a refrigerant through the compression, condensation and evaporation phases of its function involves a constantly changing physical condition. The gas at one pressure,  $\text{CO}_2$  for instance, is taken from the evaporator at 40 degrees and 535 pounds pressure—heat content about 100 Btu per pound. It is compressed to 950 pounds, the temperature rises, the heat content increases. The gas is then passed through the condenser, where the pressure remains above 900 pounds, the temperature reduced below the critical temperature of 88 degrees and the heat content reduced to around 32 Btu per pound—then to the evaporator where the pressure is reduced, the liquid evaporates and the heat of vaporization is taken from the air being treated.

Here are the fundamental physical aspects of the cycle:

- 1—Volumetric displacement in the compressor cylinder.
- 2—Volumetric efficiency of the compressor
- 3—Frictional losses of gas in the piping.
- 4—Mean temperature differences between the gas and the condenser water.
- 5—Surface and rate of heat transfer at varying gas and water velocities through the condenser.
- 6—Frictional losses of liquid in piping.
- 7—Mean temperature difference between the gas in the evaporator and the air passing over the evaporator.
- 8—Velocity of air over the evaporator.
- 9—Air dewpoint and refrigerant temperature—relation at the evaporator.
- 10—Frictional losses of gas being returned to the compressor.

These are a few mathematical angles to receive the studious attention of the designer in every individual air conditioning system. The mention of pressures up to 65 atmospheres may suggest that relatively high pressures are characteristic of refrigerants. Such is not the case. In fact, the newest developments in comfort cooling equipment uses as a refrigerant ordinary aqua lava, or plain water—but at a boiling point of about 45 degrees under a pressure of one pound, absolute.

The characteristics of water vapor under 28-inch vacuum are

just as surprising as a boiling point 13 degrees above freezing. Centrifugal blowers used to move the enormous quantities of this vapor from the evaporator to the condenser are equally interesting.

Static and dynamic balances must be, shall I say perfect, in a machine turning 6000 RPM with 100 horse-power load.

Should anyone try to convince you that there is no romance in air conditioning refer him to water at the 45 degree boiling point. Conversely, no one should be able to convince you that air conditioning is all romance.

However perfectly the air heating, cooling, humidifying or dehumidifying has been done within the equipment, or at the conditioner, there has been no comfort result in the space to be treated until and unless the conditioned air is delivered to and distributed in that space.

So common as ventilating fans are in their everyday application to ventilating systems, it will probably surprise you to know that more blowers are copied than designed. It is a notorious fact that some blower manufacturers never designed a blower. In fact, many blowers are but copies of a competitive manufacturer's products, errors and all, with a different color of paint on the outside.

The moving of very large quantities of air silently has presented many new problems and demanded serious constructive thought in blower design. The result is that far-reaching improvements have been made in blower equipment design to meet the peculiar requirements of air conditioning. This brings up the point that aerodynamics are not necessarily confined alone to airplane applications. Nor is the blower the only point where aero-dynamics touch this new industry.

The design of distributing ducts and grilles through which the conditioned air is delivered to the treated space requires and demands accurate sizing for constant frictional values and satisfactory diffusion. The development and design of patterns for curves and transition duct connections requires a thorough knowledge of trigonometry, geometry, and integral calculus.

The sound arising from air motion in ducts and through grilles, from vibrations of compressors, motors and blowers, invites a thorough knowledge of acoustics, because a good air conditioning system presupposes silent operation.

From all these sketchy remarks it will be seen that science and mathematics are very much behind air conditioning.

My object is to show you that this new industry fairly reeks with science and is saturated with mathematics. The industry has all the adventure and charm of a new toy. It is, as the advertising mind would interpret, a "dominant idea" in itself.

Through it, then, the minds of American youth will be found receptive to otherwise dry and tedious subjects. A new incentive affecting the health and happiness of everyone has been found for the study of physiology, dietetics, anatomy, chemistry, architecture, acoustics, aero-dynamics, thermo-dynamics, *all* angles of physics, and every conceivable form of mathematics from simple arithmetic to empirical logarithms, to say nothing of advanced psychology, philosophy and logic.

Furthermore, to enter into air conditioning as a life work, which is an idea readily embraced by many students in your daily contact, requires a comprehensive knowledge of these subjects. It is true that much of the industry's personnel today "came up from the ranks." Men schooled in the folklore of steam-fitting, refrigerating and ventilating trades. But the folklore of air conditioning will, in all probability, be written at least in part by these very students of yours. Neither the enthusiasm of ignorance nor the confidence of trade traditions will ever be an adequate substitute for these fundamentals now in your hands to administer.

Air conditioning presents a challenge to the young mind to develop toward a professional career. (We already have an abundance of quacks.) It is a ready-made working tool for the teacher to get the student's attention, to stimulate his interest in his school work, thereby simplifying the teacher's job and at the same time improving the teacher's handiwork.

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#### STATISTICAL SUMMARY OF AMERICAN EDUCATION

How many schools are there in the United States?

How many pupils are enrolled?

How many students graduate from high school and college each year?

How many teachers are there?

What is the income for schools?

What is the amount of school expenditures?

What is the value of school property?

Answers to these and other important questions dealing with American education the Federal Office of Education answers in its Statistical Summary of Education, 1931-32, which contains assembled facts for more than 127,000 school districts.

The Statistical Summary containing complete facts and figures on American education is available for five cents from the Government Printing Office, Washington, D. C.

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**SCIENCE QUESTIONS**

**April, 1935**

**Conducted by Franklin T. Jones, 10109 Wilbur Avenue,  
Cleveland, Ohio**

*Please send copies of Tests and Examinations to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.*

*Send your most interesting question in Biology, Chemistry, General Science, or Physics. Join the GQRA (Guild Question Raisers & Answers). Have your class answer or propose a problem or question.*

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**Perpetual Motion Problem**

**699.** *Proposed by O. B. Rose, Garrett High School, Garrett, Indiana (Elected to GQRA No. 61.)*

The following problem has proven to be rather puzzling to many Physics students.

A wooden wheel is pivoted on the side of a tank of water so that one-half revolves in the water and the other half in air. Of course wood rises in water and falls in air. Why will not the wheel revolve, thus producing perpetual motion?

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**Gas Meter Problem**

**700.** *Proposed by Allan J. Rosenthal, Senior Physics Class, Brookline High School, Brookline, Mass. (Elected to GQRA No. 65.)*

A, B, C and D are four gas meters in the same apartment house and on the same gas line. A and B are in the attic—six stories above the street. C and D are in the basement. A and C are kept at an average temperature of 70° F; B and D at 35° F. The gas is used in each instance to supply fuel for a kitchen range. The gas company's charges are at the rate of one dollar per thousand cubic feet. Which customer gets the most for his money?

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**701.** *Proposed by I. N. Warner, State Teachers College, Platteville, Wis. (Elected to GQRA No. 59.)*

Here is a problem and "formula" from a book we have in our Training School here, 8th Grade (Junior H. S.).

*Problem:* "An airplane makes 110 miles per hour with the wind and 40 miles per hour against the wind. What is the *average* rate of the plane in miles per hour?"

The book gives the *Solution:*  $\frac{110 \text{ miles} + 40 \text{ miles}}{2} = 75 \text{ miles}$ , now my question is: Is 75 miles per hour the really "average" rate of the plane? Answer.

### SIMPLE HARMONIC MOTION

702. *Proposed by Louis Stein (GQRA No. 57), Emmet Purdon (GQRA No. 58), Maxwell Reade (GQRA No. 48) and Mabel Reade (GQRA No. 59).*

*Problem:* If a body were free to oscillate/move so that it fell through a hole in the earth, through the center to the opposite surface, and return periodically, what would be its period of S.H.M.? (From "Elements of Mechanics" by Erickson.)

### A REAL EXAMINATION IN PHYSICS

703-709. *Submitted by H. F. Wiley, High School, Laconia, N. H. (Elected to GQRA No. 60.) (Please send in separate answers.)*

Nonsense should be avoided. Devote your efforts to solving problems with which you are familiar. Do well such as you do at all. A knowledge of the physical principles involved is of first importance. A clear argument must precede calculation. Calculations are performed to justify your arguments. There is a satisfaction in getting a correct result by way of computation.

703—1. Explain fully—(a) Why start a balloon for the stratosphere when the bag is but partly inflated?

(b) Why is it useless to try to raise water more than 34 feet with a suction pump?

(c) Why does a ball tossed 10 feet into the air get down to the ground at the same time whether the ball goes straight up or otherwise?

(d) Why is it impossible to stop a speeding car in less than a certain minimum distance?

704—2. Two boys together can lift just 300 pounds. On the shore of a lake lies a block of granite which measures 18 inches square and 2 feet long. The boys say that if the rock were rolled into the water they could lift it off the bottom without assistance. What is the truth and why?

705—3. Metal blocks of cast iron, copper, aluminum, lead and zinc are placed in an oven at 300 degrees C until all are at the same temperature. At room temperature, 20 degrees C, each block measures  $2 \times 2 \times 2.5$  cm. When hot these blocks are placed on a cake of ice. Compute

(a) Total heat absorbed by the metals while in the oven.

(b) The number of grams of ice which will be melted.

(c) The volume of each block when hot.

706—4. A green house is fitted with a compound bar device which causes a bell to ring in the gardener's bedroom in case the temperature drops to a certain point during the night. Make a sketch to show how this may be done. Explain fully.

707—5. Make use of the law of similar figures in solving the following problems. A solid cast iron ball is 2 inches in diam.

- (a) What does the ball weigh?  
 (b) What would be the weight if the diameter were 3 inches?  
 (c) Suppose the ball 6 inches in diam. and of aluminum. What would it weigh?  
 (d) Suppose the six-inch aluminum ball were hollow and the hole 2 inches in diameter. What would be the weight?

708—6. One ounce of gasoline vaporized and mixed with air, suddenly explodes.

- (a) What quantity of energy is liberated?  
 (b) How far could this energy lift a half ton?

709—7. Prove by mathematics that the following statement is true.

If a car skids off a bridge and drops to the rocks 80 ft. below, the shock at landing is as if the same car had collided on the highway while moving at 50 miles an hour.

### A SEMESTER TEST IN CHEMISTRY

710. Submitted by Leo R. Shogen, Carbon County High School, Red Lodge, Montana. (Elected to GQRA No. 64.)

Show all work on examination paper.

#### Part I—50 points

Write the formulae for the following:

- |                       |                        |
|-----------------------|------------------------|
| 1. silver oxide       | 6. ferric chloride     |
| 2. aluminum phosphate | 7. nitric acid         |
| 3. Calcium carbonate  | 8. Lead sulphite       |
| 4. zinc sulphate      | 9. sodium bisulphate   |
| 5. oxygen gas         | 10. potassium nitrate. |

Match the two columns by putting the letter before the statement in the second column after the condition in the first column it satisfies

- |                    |                                       |
|--------------------|---------------------------------------|
| 11. Frasch.....    | a. Argon                              |
| 12. Charles.....   | b. Extraction of sulfur               |
| 13. Cavendish..... | c. number of molecules in gas volumes |
| 14. Avagadro.....  | d. Law of reacting volumes.           |
| 15. Ramsay.....    | e. Absolute temperature               |
|                    | f. discovery of hydrogen.             |

Match the following:

- |                             |  |
|-----------------------------|--|
| 16. Potassium sulphate..... | a. Marble and hydrochloric acid.           |
| 17. Water.....              | b. test for the sulphate radical           |
| 18. Carbon dioxide.....     | c. Manganese dioxide and Hydrochloric acid |
| 19. Barium chloride         | d. sulfuric acid and potassium sulphate    |
| 20. chlorine gas            | e. hydrogen and red hot iron oxide.        |
|                             | f. electrolysis of barium sulphate         |

All atomic weights at end.

21. What per cent of copper sulphate is copper?  $\text{CuSO}_4$ .....  
 22. 55 degrees Centigrade is what absolute temperature. ....  
 23. Name a good reducing agent. ....  
 24. Oxides of non metals with water produce .....  
 25. One liter of a gas weighs .71 grams.  
     What is its molecular weight. ....  
 26. Two good indicators are ..... and .....  
 27. Write the formulae for two bases; ..... and .....

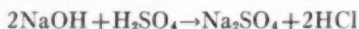
28. Miners use canaries to detect .....
29. Limewater is used in testing for .....
30. Dry ice is .....
31. One hundred volumes of air contain ..... volumes of oxygen
32. Paper, straw hats and fruits are often bleached with .....
33. What important process tends to cut down the amount of carbon dioxide in the air? .....
34. State what you believe is the most important statement in Dalton's theory. ....
35. The valence of the sulphite radical is .....
36. The acid used in a carbon dioxide fire extinguisher is .....
37. What element besides oxygen shows allotropism: .....
38. What are standard conditions? ..... mm. .... C.
39. A normal solution of  $\text{Ca}(\text{OH})_2$  contains ..... gms. per liter.
40. Oily rags catching on fire is an example of .....
41. Give a good example of a mixture .....
42. The three states of matter. ...., ..... and .....
43. Why is hydrogen chloride not collected over water in the laboratory? .....
44. In testing for hydrogen sulfide I would use .....
45. The acid anhydride of sulfuric acid is .....
46. End point is a term used in .....
47. When carbon dioxide is passed over red hot carbon ..... is formed.
48. List three radicals. ...., ....., .....
49. Name a compound that contains sulphur. ....
50. Name a catalyst. ....

*Part 2 value 50 points*

Show work

1.

A certain weight of sodium hydroxide was neutralized with sulphuric acid. The solution was evaporated and the residue  $\text{Na}_2\text{SO}_4$  weighed 10 grams. Compute the weight of sodium hydroxide used.



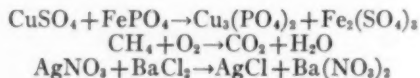
2.

Write equations for the following.

Reaction of sodium hydroxide and hydrochloric acid; reaction of hydrogen and copper oxide; reaction of sulfuric acid and zinc; reaction for burning carbon; reaction for hydrogen combining with chlorine.

3.

Balance,



4.

Using the second equation in problem three compute the amount of  $\text{CO}_2$  that will be produced by burning ten liters of  $\text{CH}_4$ .

5.

100 cc of a gas at a temperature of 50 degrees centigrade and 600 mm pressure will occupy what volume at standard conditions?

Atomic weights

Cu—63.6, S—32, O—16, Ca—40, H—1, Na—23, Cl—35.5, C—12.

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#### A Puzzler for the Thinkers

686. *Proposed by W. E. Buker, (GQRA No. 22) Leedsdale, Pa.*

A king blindfolded three of his subjects and touched each on the forehead. They knew that the finger touching them might or might not be covered with lampblack. When the blindfolds were removed, they were given instructions to start whistling if they saw one or more black spots. As soon as any one of them could figure out whether he himself had lampblack on his forehead, he was to stop whistling.

There were spots on all three foreheads, and presently A stopped whistling. How did he know he had lampblack on his forehead?

*Answer offered by Robert Wood, Chemistry Class, (Elected to GQRA No. 62) Albion High School, Albion, N. Y.*

"I stopped whistling because I noticed that as soon as one of the other two boys looked at my forehead, he started to whistle before looking at the third of the group, therefore, I knew that I had some lampblack on my forehead. Otherwise he would not have begun whistling before looking at the third person."

*Answer by O. B. Rose (GQRA No. 61) Garrett High School, Garrett, Ind.*

Black spots were placed on the foreheads of Tom, Dick, and Harry. All began whistling, of course. Soon Tom stopped whistling. He had reasoned as follows: "Suppose I did not have a black spot on my forehead. Then Dick would stop whistling because he would know that Harry, not seeing any black spot on my head, was whistling at his (Dick's) head. But Dick did not stop whistling so I must have a black spot."

*Also answered by Carl E. Heilman, Paulsboro, N. J. (GQRA No. 55.)*

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#### IRRESISTIBLE VS IMMOVABLE

684. *Question proposed by Rawlins S. Cooke, (GQRA No. 53) Steuben H. S., Milwaukee, Wis.*

"When an irresistible force strikes an immovable object, what will happen?"

*Answer by Charles C. D'Amico (GQRA No. 49) Albion, N. Y.*

Mr. Jones, my answer to the above question is a mere speculation and opinion. I submit the following discussion with apologies. This question has been debated and argued on many an occasion and the results have been far from conclusive.

An immovable object has infinite inertia. Newton's first law of motion defines inertia of matter as the property by virtue of which matter cannot itself change its own state of motion or of rest. If a body is at rest, it

remains in that state until force acts upon it. The inertia of a body, therefore, is the resistance which it opposes to any change of its state whether of rest or of motion. In this case the resistance which the immovable object offers, must also be irresistible. Thus we have two equal and opposite irresistible forces opposing each other. The resultant is zero. The motion of the irresistible force is impeded by the friction against the immovable object. All motion is of necessity ultimately converted into heat by the agency of friction. Thus the two forces tend to destroy each other and the mechanical energy expended appears as heat (First Law of Thermodynamics).

### FRICTIONLESS MOTION

**685.** *Proposed by Rawlins S. Coke, (GQRA No. 53) Milwaukee, Wis.*

"Two boys stand together out in the middle of a lake on the surface of level ice with ice skates attached to their shoes. Suppose that the movement of the skates on the ice is frictionless, without taking off their skates or calling for any external help, how are they to get ashore?"

*Answer by David Woods, Chemistry and Physics Classes, Albion High School, Albion, N. Y. (Elected to GQRA No. 63.)*

"The two boys could easily get to shore. All they need do is breathe or blow. The reaction (Newton's Third law) of their breath against the air would push them toward the shore."

### Would all of Miss Peter's Boys Steal Ice Cream

**677.** *Proposed by L. E. Hebl, Woodriver, Illinois. (Elected to GQRA No. 40.)*

Miss King learned, by some means or other, that two of the seven boys who stole the ice cream for her class picnic wore long pants. Thereupon she accused all the boys of Miss Peter's class of participating in the theft because there were just seven boys in Miss Peter's class. Miss Peters couldn't believe that all her boys would steal because none of the rascally Johnsons or Joneses were in her class (the Johnson and Jones boys were the only red-headed boys in the school). The principal, Miss Smith, settled the question quickly with the observation that all the boys over ten years old had red hair and all those under ten wore short pants, and that therefore at least some of the boys who stole Miss King's ice cream must have been from one of the other classes besides Miss Peter's. Why?

*Comment by Carl E. Heilman, Paulsboro, N. J. (Elected to GQRA No. 55.)*

"Perhaps my mental processes are at fault: but I find myself compelled to take issue with the solution proposed by Mr. Maxwell Reade as to whether *all* of Miss Peters' boys would stoop to such a despicable act as to steal ice cream. Mr. Reade, in his solution, bases his reasoning upon the premise that *all* boys over ten wear long pants, a statement for which I can find no basis in the problem, which merely says that 'all under ten years wear short pants'; and, as I see it, that does not prevent some over ten from wearing short pants also. As I see the question, it is indeterminate, and Miss Smith is somewhat hasty in her conclusion."

*Please check Mr. Reade's answer and Mr. Heilman's comments with the solution Mr. Hebl gives to his own problem.*

*Solution by L. E. Hebl (GQRA No. 40). Woodriver, Ill.*

- A: From Miss Smith's observations,  
 (1) All the boys over ten had red hair.  
 (2) All those wearing long pants were over ten.  
 Thus all those wearing long pants had red hair.
- B: Miss Peters' class and the Johnsons and Joneses:  
 (1) None of the Johnsons or Joneses were in Miss Peter's class.  
 (2) The Johnsons and Joneses were the only ones having red hair.  
 Thus one of Miss Peter's boys had red hair.
- C: From A and B:  
 None of Miss Peter's boys wore long pants.
- D: Miss King knew:  
 Some of the boys who stole the ice cream wore long pants.
- E: From C and D:  
 Some of the boys who stole the ice cream were not in Miss Peter's class.

## PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

*State Teachers College, Kirksville, Mo.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution as on the following pages.*

*The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.*

## SOLUTIONS AND PROBLEMS

**NOTE.** Persons sending in solutions and submitting problems for solutions should observe the following instructions

1. Drawings in India ink should be on a separate page from the solutions.
2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.
3. In general when several solutions are correct, the one submitted in the best form will be used.

## LATE SOLUTIONS

1361, 1363. *J. B. King, Corsica, Pa.*

1369. *J. B. King, Corsica, Pa., William Kent, Spokane, Washington.*

1358, 1359, 1360, 1362. *David Gordon, Woodbine, N. J. Jerome Formo, Minneapolis, Max Fowler, Centralia, Illinois.*

1370. *Proposed by Hugh L. Demmer, Custer, S. D.*

(a) A cess pool pit is to be dug with the following dimensions: the top is 14 feet by 16 feet, the bottom is 10 feet square; and the depth is 8 feet.

All four of the sides slope gradually from top to bottom. The work is to be paid for by the number of cubic feet of earth removed. Calculate the volume in two ways: (1) By the Prismatoid Formula; and (2) by adding the volumes of the regular solids obtained by sectioning the entire figure.

(b) Why is the following solution incorrect? The volume is equal to: average length  $\times$  average width  $\times$  depth, or  $13 \times 12 \times 8$ , or 1248 cu. ft.

(c) Why is the following solution incorrect? The volume is equal to: depth  $\times$  average of top and bottom areas, or  $8 \times \frac{1}{2}(224 + 100)$ , or 1296 cu. ft.

$$(a). \text{ By the Prismatoid Formula: } V = \frac{h}{6}(B + b + 4m), \text{ or } \frac{8}{6}(224 + 100 + 4$$

$\times 156)$ , or 1264 cubic feet.

By sectioning the figure into a center rectangular solid, two pairs of triangular prisms at the sides, and four pyramids at the corners:

$$V \text{ (rectangular solid)} = Bh = 100 \times 8 = 800 \text{ cubic feet.}$$

$$V \text{ (two equal triangular prisms at the sides)} = 2 \times Bh = 2 \times \left(\frac{1}{2} \times 8 \times 2\right) \times 10 = 160 \text{ cubic feet.}$$

$$V \text{ (two equal triangular prisms at the ends)} = 2 \times Bh = 2 \times \left(\frac{1}{2} \times 8 \times 3\right) \times 10 = 240 \text{ cubic feet.}$$

$$V \text{ (four equal pyramids at the corners)} = 4 \times \frac{1}{3} Bh = 4 \times \frac{1}{3} \times 8 \times 2 = 64 \text{ cubic feet.}$$

$$\text{Total Volume} = 1264 \text{ cubic feet.}$$

(b). The error in this solution lies in the computation of the volume of the pyramids at the corners. It assumes that the volume of a rectangular pyramid is equal to the volume of a rectangular solid having a base with one-half the length and one-half the width of the base of the pyramid. This would give  $\frac{1}{2}Bh$  as a formula for the volume of a rectangular pyramid, and would introduce an error of  $-4$  cubic feet for each corner, or a total error of  $-16$  cubic feet.

(c). The error in this solution also lies in the computation of the volume of the pyramids at the corners. It assumes that the volume of a rectangular pyramid is equal to  $\frac{1}{2}(B + b)h$ , or since the upper base of a pyramid is zero,  $\frac{1}{2}Bh$ . This would introduce an error of  $+8$  cubic feet for each corner, or a total error of  $+32$  cubic feet.

A solution also offered by Maxwell Reade, Brooklyn, W. E. Buker, Leetsdale, Pa. and Chas. C. D'Amico.

**1371.** *Proposed by W. E. Buker, Leetsdale, Pa.*

Find the point the sum of whose distances from the three sides of a triangle is a minimum.

*Solved by Aaron Buchman, Buffalo, N. Y.*

Given  $\triangle ABC$ ,  $h_a \perp a$

Let  $a > b, c$  (1)

Let  $P$  be any point within or on  $\triangle ABC$  except vertex  $A$ , and let  $h_1 \perp a$ ,  $h_2 \perp b$ ,  $h_3 \perp c$

Draw  $PA$ ,  $PB$ ,  $PC$  forming  $\triangle PAB$ ,  $\triangle PBC$ ,  $\triangle PCA$

Then  $ah_1 + bh_2 + ch_3 = ah_a$  (2)

But from (1)  $ah_2 > bh_2$ ,  $ah_3 > ch_3$  (3)

From (2) and (3)  $ah_1 + ah_2 + ah_3 > ah_a$

and  $\therefore h_1 + h_2 + h_3 > h_a$  (4)

Let  $P$  be without  $\triangle ABC$

By a procedure similar to the above we now get

$$\begin{aligned} ah_1 + bh_2 + ch_3 &> ah_a \text{ and finally} \\ h_1 + h_2 + h_3 &> h_a \end{aligned} \quad (5)$$

From (4) and (5) we conclude that  $A$  is the point, the sum of whose distances from the three sides of  $\triangle ABC$ , is a minimum.

Solutions also offered by J. B. King, Corsica, Pa., and the South Philadelphia H. S. Mathematics Club.

**1372.** *Proposed by Norman Anning, University of Michigan.* Show that  $2 \sin 18^\circ = \sqrt{2 - \sqrt{2 + \sqrt{2 - \sqrt{2 + \dots}}}}$  endlessly.

*Solution by Roy MacKay, Eastern New Mexico Junior College*

$$\begin{aligned} 2 \sin 18^\circ &= 2 \cos 72^\circ = 4 \cos^2 36^\circ - 2. \text{ Therefore} \\ \sqrt{2 + 2 \sin 18^\circ} &= 2 \cos 36^\circ = 2 - 4 \sin^2 18^\circ, \end{aligned}$$

$$\begin{aligned} \text{whence} \quad 4 \sin^2 18^\circ &= 2 - \sqrt{2 + 2 \sin 18^\circ}, \text{ or} \\ 2 \sin 18^\circ &= \sqrt{2 - \sqrt{2 + 2 \sin 18^\circ}}. \end{aligned}$$

By continued substitution in this recurring relationship the desired expansion results.

Solutions also offered by Aaron Buchman, Buffalo, N. Y., Richard A. Miller, Univ. of Mississippi, H. Leo Juditz, College of the City of New York, Julius Freilich, Brooklyn, N. Y., and the Proposer.

**1373.** *No solutions have been offered.*

**Problem. 1374.** *Proposed by Henry Luster, Philadelphia.*

When will the hands of a stop watch that measures fifths of a second, seconds, minutes and hours be perpendicular to each other in this order: the second hand, the hour hand, the minute hand and the one-fifth second hand. Start at 12 and proceed in clockwise order.

*Solution by W. E. Buker, Leetsdale High School, Leetsdale, Pa.*

Starting with all hands together at 12, let the minute hand pass over  $x$  spaces. In the same time the hour hand will pass over  $x/12$  spaces.

If the minute hand is  $90^\circ$  or 15 minute spaces ahead of the hour hand,

$$x - x/12 = 15 + 60n \quad (n=0, 1, 2, 3, \dots, 10), \text{ so} \quad (1)$$

$$x = 16 \frac{4}{11}, 81 \frac{9}{11}, 147 \frac{3}{11}, \dots, 670 \frac{10}{11}. \quad (2)$$

Thus, the condition that the minute hand must be  $90^\circ$  ahead of the hour hand is fulfilled only eleven times during one complete cycle of the clock; and the number of minutes past 12 at which these conditions are fulfilled is represented by the values of  $x$  in (2). The only value of  $x$  which is not a fraction with denominator 11 is  $x=540$ , which is the situation at 9 o'clock.

While the minute hand passes over  $x$  spaces, the second hand passes over  $60x$  spaces, and so gains  $59x$  spaces on the minute hand. Now, since the second hand and minute hand are exactly 30 minute spaces apart, the amount which  $59x$  represents must be an integer. That is, any number of minutes past 12 which is a solution must be one of the values of  $x$  in (2); and must be such that  $59x$  is an integer. Obviously, the only possible value of  $x$  in (2) is  $x=540$ . But since the minute and second hands are together on 12 at 9 o'clock, that value of  $x$  is not a solution.

So, even if we disregard entirely the one fifth second hand and the conditions referring to it, the above argument shows that the hour, minute

and second hands are never in the positions indicated, and the problem has no solution.

**1375.** *Proposed by Allen A. Shaw, University of Arizona.*

Given  $A, B, C, D$  collinear, prove, by partial fractions, Euler's theorem:

$$BC \cdot AD + CA \cdot BD + AB \cdot CD = 0$$

*Solution by Norman Anning, University of Michigan.*

Let  $\frac{d-c}{(d-a)(d-b)} = \frac{A}{d-a} + \frac{B}{d-b}$  (1) from which by the usual method we obtain  $(a-c) = A(a-b)$  and  $(b-c) = B(b-a)$ .

Inserting these values of  $A$  and  $B$  in (1), clear of fractions and rearrange. This results in the equation

$$(c-b)(d-a) + (a-c)(d-b) + (b-a)(d-c) = 0 \quad (2)$$

To obtain Euler's Theorem we set up a number scale with 0 as origin and interpret  $a, b, c, d$ , as  $OA, OB, OC, OD$ . Equation (2) then becomes by using the distance formula for points on a straight line  $BC \cdot AD + CA \cdot BD + AB \cdot CD = 0$ . A solution was also offered by the proposer.

### HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

**1371.** S. Philadelphia Math. H. S. Club.

### PROBLEMS FOR SOLUTION

**1388.** *Proposed by Dewey C. Duncan, University of California.*

A spider from the vertex of a regular tetrahedron sets out to traverse in the shortest possible way the six edges at least once each and return to the starting point. If each edge is 1 foot long how far does it travel? How many different courses could it pursue in performing the journey if courses performed in opposite directions are regarded as different.

**1389.** *Proposed by Charles W. Triggs, Cumnock College, Los Angeles.*

In the triangle  $ABC$ ,  $E$  is a point on  $AC$  such that  $AE = AB$ . Find the length of  $BE$  in terms of the sides,  $a, b, c$ , of the triangle.

**1390.** *Proposed by Maxwell Reade, Brooklyn*

If  $\frac{a-b}{a-q} = \frac{b-p}{q-b}$ , prove that  $\frac{1}{(a-p)(a-q)} - \frac{1}{(b-p)(q-b)} = \frac{-4}{(a-b)^2}$ .

**1391.** *Proposed by Hugh L. Demmer, Custer, South Dakota.*

Find an approximate solution to the equation  $X + \log_{10} X = 10$ .

1392. *Proposed by Adrian Strunk, Paterson, N. J.*

$AD$  is the altitude upon the hypotenuse  $BC$  of the right triangle  $ABC$ .  $X, Y, Z$  are non-collinear points whose distances from a fixed point  $O$  are such that  $OX = AB, OY = AC, OZ = AD$ .  $OX, OY, OZ$  (or  $XO, YO, ZO$ ) produced meet the circle  $XYZ$  in  $X', Y', Z'$  respectively. Prove that a right triangle exists with hypotenuse equal to  $OZ'$ , and legs equal to  $OX'$  and  $OY'$ .

1393. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Prove: If the focus of any parabola coincides with the center of any circle, and the vertex of the parabola lies within the circle, then the tangent to the parabola at its vertex bisects every chord of the circle, which, extended if necessary, is tangent to the parabola.

### EXPENDITURES FOR EDUCATION

Including schools in Alaska and Government schools for Indians, the expenditure for all levels of education, public and private, the Federal Office of Education reveals was \$2,968,019,400, according to last reports. (Elementary, \$1,700,000,000; High School, \$700,000,000; College, \$544,000,000.) All publicly supported education could have been paid for if each person of voting age would have contributed 9 cents a day in 1932, the Federal Office of Education announces. About 2 cents in addition would have paid the bill for private education. The annual expenditure per adult for public education was \$32.95, and for private education, \$7.10.

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## BOOKS AND PAMPHLETS RECEIVED

*A Brief Course in College Algebra*, by Walter Burton Ford, Professor of Mathematics, The University of Michigan. Third Edition. Cloth. Pages vii+304. 12.5×19 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price \$1.90.

*Principles of Genetics and Eugenics*, by Nathan Fasten, Professor and Head of Department of Zoology, Oregon State College. Cloth. Pages viii+407. 14×21 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price \$2.80.

*My Own Science Problems*, by George W. Hunter, Lecturer in Methods of Education in Science, Claremont Colleges, California, and Walter G. Whitman, Department of Physical Science, State Teachers College, Salem, Massachusetts. Cloth. Pages xiv+429. 12.5×20 cm. 1935. American Book Company, 330 East Cermak Road, Chicago, Illinois.

*Science in Our Social Life*, by George W. Hunter, Lecturer in Methods of Education in Science, Claremont Colleges, California, and Walter G. Whitman, Department of Physical Science, State Teachers College, Salem, Massachusetts. Cloth. Pages xiv+452. 12.5×20 cm. 1935. American Book Company, 330 East Cermak Road, Chicago, Illinois.

*Science in Our World of Progress*, by George W. Hunter, Lecturer in Methods of Education in Science, Claremont Colleges, California, and Walter G. Whitman, Department of Physical Science, State Teachers College, Salem, Massachusetts. Cloth. Pages xv+581. 13.5×20 cm. 1935. American Book Company, 330 East Cermak Road, Chicago, Illinois.

*General Science, A Guide for Students*, by General Science Teachers of Cleveland Heights, Ohio. Paper, 134 pages, 15×23 cm. 1934. Published by Cleveland Heights Board of Education, Cleveland Heights, Ohio. Price \$1.00.

Additions in Arithmetic, 1483-1700, to the Sources of Cajori's "History of Mathematical Notations" and Tropsfke's "Geschichte der Elementar-Mathematik," by Sister Mary Leontius Schulte of the Sisters of Saint Francis, Rochester, Minnesota. Paper. Pages 99+x. 13.5×21 cm. 1935.

*Dark Field Optical Systems*, by Bausch and Lomb Optical Co., Rochester, New York. Paper. 16 pages. 15.5×23 cm. 1934.

*Mind, The Maker*, The World Theory of the late William Benjamin Smith presented by Cassius Jackson Keyser, Adrain Professor Emeritus of Mathematics in Columbia University. Paper. 31 pages. 12×19 cm. 1934. Published by Scripta Mathematica, Yeshiva College, Amsterdam Avenue and 186th Street, New York, N. Y. Price 35 cents.

## BOOK REVIEWS

*Theoretical Physics*, by George Joos, Professor of Physics at the University of Jena. Translated by Ira M. Freeman, Ph.D. Cloth. 14×21 cm. Pages xxiii+748. 1934. Blackie & Son, Limited, London. Price 25s net.

During the past few years many texts on Theoretical Physics have appeared; none, however, as complete and thorough as this text. The work covers the whole field of Applied and Theoretical Physics, both classical and modern. The carefully selected material gives a unified summary of the entire field. The author does not purport that this is a royal road by which the student may add to his repertoire the various branches of theoretical physics. With careful perusal of the text one receives definite training in the methods of theoretical physics. The

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reviewer had occasion to work through in detail the entire sections on Vector Analysis and on Electrostatic Fields. In the former was found one of the clearest presentations of gradients, curls and operators. The very concise style requires diligent reading.

Part I includes selected topics in the Calculus of Variations and Functions of a Complex Variable. Those topics in other sections which require very exacting mathematical treatments are sketched by presenting the physical train of thought. The problems form an integral part of the text. Solutions for most are found in the rear of the text. To become thoroughly conversant with the material one should have a knowledge of the theory of functions.

The last chapter deals with the very recent experiments on artificial disintegration.

Dr. Freeman has done English students a great service by giving such an able translation of this book which reads as if the original was written in English.

#### C. RADIUS

*Biology*, by Frederick L. Fitzpatrick, Teachers College, Columbia University, New York, and Ralph E. Horton, Chairman, Department of Science, Seward Park High School, New York City. Cloth. xiv + 611 + xlv pages. 266 figures and 4 full page colored plates. 12 mo. Published by Houghton Mifflin Company, Boston. 1935. Price \$1.76.

This text seeks to present a revised course of study in general biology, bringing the course up to the latest proposals for the teaching of this subject. It attempts to "emphasize those biological principles which have applications in everyday experiences." The materials of the book have been arranged by the authors in seven units, each unit dealing with a specific fundamental principle of biology. The units are as follows: *First*, a general introduction, discussion of the changing environment and the history of human progress in that environment; *second*, cell principle, exhibited by the structure of plants and animals; *third*, physiology and energy phenomena; *fourth*, adaptations of function and structure; *fifth*, reproduction; *sixth*, variation and heredity; *seventh*, other organisms in relation to human welfare.

At the end of each chapter appear "instructional guides," including "suggested activities," a "summary of principles," "guide questions to be used as a basis of class discussion," and "a list of books to read." The fifth chapter, *The History of Mankind*, illustrates the author's method of treating a subject and is moreover a good illustration of the *new* in the course in biology presented by these authors. We give a list of topics for this chapter: Problems proposed, foreword, knowledge of primitive man, fossils and relics of man, Java man, Heidelberg and Neanderthal man, Piltdown man, Cro-Magnon man, life of primitive man, hunting and fishing stage, herding, agriculture, trading, beginning of historical records, the mediaeval period, rise and fall of cultures, modern civilization, homology, classification of groups, the scientific name, improvement of environment, cultivated plants, domesticated animals, destruction of undesirable species, competitors and natural enemies of man, other changes in the environment, progress in civilization, science and man's success, and for the student, suggested activities, summary of principles, guide questions, and books to read.

We can easily see in glancing over the topics for this chapter that the treatment is very comprehensive and interesting. There is a logical development of the subject which will give the student a satisfying grasp of man's progress in the life of the world. We like the book. It is fresh,

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This textbook presents a complete course in the fundamentals of college mathematics, covering college algebra, trigonometry, analytic geometry, differential and integral calculus. The text is planned to enable use in courses of different lengths. All material has been thoroughly tested in class use. The authors are Arthur Tilley, H. E. Wahlert, and C. H. Helliwell of New York University. To be published in April. Probable price, \$3.50

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gets away from the hackneyed methods of old. The make-up of the book is all that can be desired. The illustrations are numerous, well chosen, and helpful. We congratulate the authors on their success.

W. WHITNEY

*A Textbook of Physics*, by E. Grimsehl; edited by R. Tomaschek, Professor of Physics, the University of Marburg; Authorized Translation from the Seventh German Edition by Winifred M. Deans. Volume IV, Optics. Cloth. Pages xii+301. 14.5×22 cm. 1933. Blackie & Son, Limited, 50 Old Bailey, London, E.C. 4. Price 15s net.

That this textbook is somewhat unusual is evident from the beginning since the first sentence refers to light as an electromagnetic wave motion. A large part of the first chapter is devoted to a discussion of diffraction phenomena and theory. Preparation for this has, however, been made by a complete discussion of wave motion in a previous volume. A brief chapter on photometry and light intensity follows. The section on geometrical optics, consisting of four chapters is thorough and comprehensive. Particular stress is given to lens systems, defects, corrections, and applications. The sections on dispersion and interference are sufficient for practically all undergraduate work. The text is completed by brief chapters on the determination of the speed of light, polarization, and optical phenomena in the atmosphere.

The descriptive material is supplemented by many photographs and drawings. The mathematical developments are complete. Only elementary mathematics is used. The presentation throughout is excellent.

G. W. W.

*Intermediate Algebra*, by Aaron Frelich, Chairman of the Department of Mathematics, Buschwick High School, Brooklyn, New York; Henry H. Shanholt, Chairman of the Department of Mathematics, Abraham Lincoln High School, Brooklyn, New York; and Joseph P. McCormack, Chairman of the Department of Mathematics, Theodore Roosevelt High School, Bronx, New York. Pages ix+406. 1934. Silver-Burdett and Company, New York.

*Plane Trigonometry*, by Aaron Frelich, Henry H. Shanholt, and Joseph P. McCormack. Pages ix+293. 1934. Silver-Burdett and Company, New York.

*Fusion Mathematics*, by Aaron Frelich, Henry H. Shanholt, and Joseph P. McCormack. Pages vii+600, 1934. Silver-Burdett and Company, New York.

This list of three books in mathematics by the three authors who have had wide experience in the teaching of secondary mathematics consists of advanced work in algebra, plane trigonometry, and a correlation of advanced algebra and trigonometry as a separate text. The first two texts are intended to be used separately, each consisting of a semester's work while the third text offers the work of these two courses in one volume intended to be used two semesters.

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These textbooks deserve a careful consideration by the teachers of high school mathematics. By the fusion of mathematical processes and concepts, the authors have made a contribution to the pedagogy of mathematics.

J. S. GEORGES

*The Teaching of Arithmetic*, by Paul Klapper, Dean of the School of Education, College of the City of New York. Cloth. Pages xiii+525. 13×20 cm. 1934. D. Appleton-Century Company, 35 West 32nd Street, New York. Price \$2.60.

The author has three primary objectives: First, to arouse a discontent with the teaching procedures that are based chiefly on personal opinion rather than research. Second, to justify certain teaching techniques by accredited principles of psychology. Third, to make the student realize that emphasis must be placed on learning rather than on teaching arithmetic. The book discusses the objectives, the course of study, the organization of the material, the psychological considerations influencing teaching, and the supervision of teaching. The second half is devoted to the study of how special topics should be taught—not only the customary topics of the lower grades, but also measurement, the metric system, business forms, graphs, and the solving of problems. There is also a ten-page bibliography and a collection of samples of standardized tests and related material. High School teachers although not directly concerned about the teaching of elementary arithmetic could profit by a study of the first half of this book.

J. A. NYBERG

*The Professional Treatment of the Subject Matter of Arithmetic for Teacher-Training Institutions, Grades I to VI*, by Elias A. Bond. Contribution to Education, No. 525. Cloth. 315 pages. 15×23 cm. 1934. Bureau of Publications, Teachers College, Columbia University. New York. \$2.50.

This is a splendid organization of the material that should form the courses for the training of teachers of arithmetic. Each topic in arithmetic now studied in the elementary schools is treated under the following heads: (1) The history of the topic and the development of the present techniques of teaching it. (2) The social use of the topic. (3) The mathematical principles that are involved. (4) The psychology and the experimental work that has been done. (5) The selection of activities for teaching the topic. (6) Provisions for reaching proficiency in teaching. (7) Suggested readings. This arrangement of the material makes the book especially useful as a

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*A First Course in Algebra*, by N. J. Lennes. Macmillan Company. 1934. Price \$1.36. xii+456 pp.

In the preface to this text the author states that the course proposed devotes itself to algebra in a straight forward way. This it certainly does, but one should not falsely conclude that geometry has been omitted for throughout the book the author has skillfully interwoven the subject matter of algebra and such material from geometry as he feels will aid the student in mastering the concepts of algebra.

The reviewer has found that many modern pedagogical principles have been used in construction of *A First Course in Algebra*. For example, we find that there is a section devoted to a historical sketch of mathematics, another to supplementary material for the brighter pupil, still another to a synopsis of the subject matter of the text, and finally a section devoted to review material. The reviewer feels, however, that it would have been educationally more sound to have woven these sections into the material suggested for a minimum course. Throughout the text one finds a wealth of problem material.

G. L. ROYCE

*First-Year Algebra*, by Herbert E. Hawkes, Ph.D., Professor of Mathematics in Columbia University; Wm. A. Luby, A.M., Head of Department of Mathematics in the University of Kansas City; and Frank C. Touton, Ph.D., Professor of Education in the University of Southern California. Ginn and Co. 1934. Price \$1.32. vii+482 pp.

The authors of *First-Year Algebra* have done an exceedingly fine job of revision of their previous text. In the text one finds a wealth of problems both for oral and written work. An important addition is the historical notes placed near the related text.

The reviewer can only offer one criticism of this text, namely, that the authors have written a pure 'algebra', that is, they have excluded as much geometry as possible except for the chapters on graphing and trigonometry.

G. L. ROYCE

*Analytic and Vector Mechanics*, by Hiram W. Edwards, Associate Professor of Physics, University of California at Los Angeles. Cloth. Pages x+428. 14.5×23 cm. 1933. McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York. Price \$4.00.

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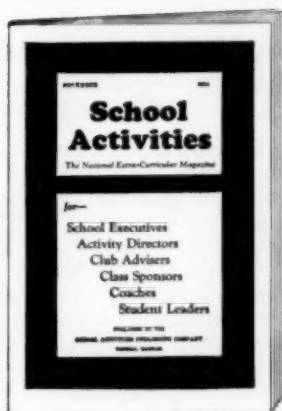
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